The Canadian Defence Input-Output Model

DIO Version 4.1

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Defence Economics Team

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Technical Memorandum

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Dedicated to the memory of Reg Lian.

Abstract

The Department of National Defence (DND) spends over $10 billion per year on goods and services mostly purchased from Canadian suppliers. The economic activity generated by DND purchases is typically assessed using National Input-Output models developed by Statistics Canada. Using Statistics Canada's latest economic data, the Centre for Operational Research and Analysis's Defence Economics Team developed a tailored Input-Output model adapted to the defence industrial sector. The Defence Input-Output model version 4.1 (DIO 4.1) builds on past Input-Output models developed by the Centre for Operational Research and Analysis and features for the first time an interactive and Excel-based user interface. With DIO 4.1, DND staff can run simulations to assess the domestic impact of decisions regarding major equipment purchases and improve on the quality of impact assessments. This technical memorandum documents the economic foundation of Input-Output models as well as the calculations behind DIO 4.1 and a short user guide.

Résumé

Le ministère de la Défense nationale (MDN) consacre plus de 10 milliards de dollars par an à l'achat de produits et services provenant essentiellement de fournisseurs canadiens. L'activité économique générée par les achats du MDN est habituellement évaluée à l'aide du modèle national des entrées-sorties mis au point par Statistique Canada. À l'aide des plus récentes données économiques recueillies par Statistique Canada, l'équipe des économistes de la défense du Centre d'analyse et de recherche opérationnelle (CARO) a créé un modèle d'entrées-sorties adapté à l'industrie de la défense. La version 4.1 du modèle prend appui sur de précédents modèles d'entrées-sorties mis au point par le CARO et offre pour la première fois une interface utilisateur interactive Excel. Grâce à la version 4.1, le personnel du MDN peut exécuter des simulations pour évaluer l'incidence nationale de grands achats d'équipement et améliorer la qualité des études d'impact. Le présent mémorandum technique explique les fondements économiques des modèles d'entrées-sorties et les calculs qui ont donné naissance à la version 4.1, ainsi qu'un bref guide de l'utilisateur.

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Executive summary

The Canadian Defence Input-Output Model - DIO Version 4.1
B. Solomon and T. Yazbeck; DRDC CORA TM 2011-147; Defence R&D Canada - CORA; September 2011.

Context

The Department of National Defence (DND) spends over $10 billion/year on goods and services mostly purchased from Canadian suppliers. The economic activity in Canada generated by the purchase is generally assessed through Input-Output (I-O) models developed by Statistics Canada (National I-O models).

Although Statistics Canada I-O models can be used to assess the impact of DND expenditures on the Canadian economy, they provide only an indistinct assessment of DND spending impact due to the military/specialized nature of some of the goods and services purchased.

The Defence Economics Team at the Defence Research and Development Canada Centre for Operational Research and Analysis (DRDC CORA) was tasked to develop a tailored Input-Output (I-O) Model based on Statistics Canada's (SC) data. The model developed by the Defence Economics Team highlights the military-industrial sector by aggregating the SC data which is less relevant to DND staff and providing details of the industrial sectors and commodities related to DND activities. By doing so, the model provides a way to improve the quality of impact assessment of DND spending on the Canadian economy. The new model also allows DND staff, such as Director Strategic Finance and Costing (DSFC), to run simulations to assess the domestic impact of decisions on major equipment purchases.

Defence Input-Output Model

In general, I-O models are accounting tools designed to track interindustry relationships and regional flows of production. As such, I-O models can be used to estimate the economic impacts of a defence project or government programme on the national or local economy. In order to perform calculations in a meaningful way, I-O models typically require a large amount of economic data and a high level of precision.

The economic data required to run the DND I-O model is provided by Statistics Canada Industry Accounts Division and represents a model of the Canadian economy. The SC data includes information on the intermediate and primary inputs required to produce different products, the details of the production of each industry (output type and volume) as well as the economic activities of the different agents of the economy (from households to governments).

DIO 4.1 is grounded in the economic principle of general equilibrium developed by Leontief and as a result assumes some linearity between inputs and outputs. The various outputs

of the DND I-O model illustrate the way in which defence expenditures, expressed in terms of a standard list of 713 commodities, affect different sectors of the Canadian economy either directly or indirectly, in terms of revenues and job creation potential.

The Defence Input-Output model version 4.1 builds on previous I-O models developed within CORA. The new model is based on the most recent data available from SC and also introduces for the first time an interactive Excel-based interface to facilitate data entry and the exploration of outputs.

Limitations

As with all I-O models, there are important limitations to DIO 4.1. A first set of limitations is related to the publicly available SC data which is typically dated by three to five years and also partially censored for reasons of confidentiality. A second set of limitations results from the static nature of the model. While I-O models can quantify economic impact in terms of jobs and output ($) they do not provide any indication of the dynamics of the impact. In other words, the time over which the impact could play out and the second-level effects are not known although spill-over effects into other industries are modeled using some simple assumptions.

The Leontief assumptions also imply linearity in the production factors, i.e. the constant proportionality of inputs and outputs. As a result the model does not consider technological progress or possible economies of scale.

Finally, Input-Output models are not explicit about variations in consumer behavior. In the context of a recession for instance household may have more incentive to save or to substitute one product for another to adapt to changing prices.

Conclusion

Despite some limitations, DIO 4.1 provides an interactive and easy to use interface to run simulations and compare the impact of different decisions concerning DND expenditures. Through scenario exploration, DIO 4.1 provides a way to improve the general quality of DND impact assessment for DND staff outside of CORA. DIO 4.1 is also a reusable tool for the OR community for future economic impact studies.

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B. Solomon and T. Yazbeck ; DRDC CORA TM 2011-147 ; R&D pour la défense Canada - CARO ; Septembre 2011.

Contexte

Le ministère de la Défense nationale (MDN) consacre plus de 10 milliards de dollars par an à des produits et services achetés essentiellement auprès de fournisseurs canadiens. L'activité économique générée par les achats du MDN est généralement évaluée à l'aide du modèle national d'entrées-sorties mis au point par Statistique Canada.

S'il est vrai que les modèles d'entrées-sorties de Statistique Canada peuvent servir à évaluer l'incidence des dépenses du MDN sur l'économie canadienne, ils n'en donnent qu'une idée vague étant donné la nature militaire spécialisée de certains des produits et services achetés.

L'équipe des économistes de la défense du Centre d'analyse et de recherche opérationnelle de Recherche et développement pour la défense Canada (RDDC CARO) s'est vu confier la tâche de mettre au point un modèle d'entrées-sorties sur mesure à l'aide des données de Statistique Canada. Ce modèle adapté met en relief l'industrie militaire en regroupant les données de Statistique Canada qui présentent moins d'intérêt pour le personnel du MDN et en donnant des précisions sur les secteurs et produits industriels connexes aux activités du MDN. Ce modèle permet ainsi de mieux évaluer l'incidence des dépenses du MDN sur l'économie canadienne.

Ce nouveau modèle permet aussi au personnel du MDN, et notamment celui du Directeur - Finances et établissement des coûts (Stratégie) (DFECS), d'exécuter des simulations pour évaluer l'incidence nationale des grands achats d'équipement.

Modèle d'entrées-sorties de la Défense

De façon générale, les modèles d'entrées-sorties sont des outils de comptabilité destinés à définir les liens entre les industries et les flux de production régionaux. Par conséquent, les modèles d'entrées-sorties peuvent servir à estimer les incidences économiques d'un projet de défense ou d'un programme gouvernemental sur l'économie nationale ou locale. Pour que les calculs soient significatifs, les modèles doivent intégrer une grande précision et une importante quantité de données économiques.

Les données économiques requises pour l'exécution du modèle d'entrées-sorties du MDN proviennent de la Division des comptes de l'industrie de Statistique Canada et reflètent l'économie canadienne. Les données de Statistique Canada renseignent sur les intrants primaires et intermédiaires requis dans la production de divers produits, les particularités de la production de chaque industrie (type et volume de production) ainsi que sur les activités économiques des différents agents économiques (des ménages aux pouvoirs publics).

Le modèle 4.1 est fondé sur le principe économique de l'équilibre général mis de l'avant par Leontief et suppose par conséquent une certaine linéarité entre les entrées et les sorties. Les diverses sorties du modèle du MDN sont indicatives de la façon dont les dépenses de défense, exprimées selon une liste uniformisée de 713 produits, se répercutent sur les différents secteurs de l'économie canadienne, que ce soit directement ou indirectement, au chapitre du revenu et de la création d'emplois.

La version 4.1 du modèle d'entrées-sorties de la Défense prend appui sur de précédents modèles mis au point par CARO. Ce nouveau modèle est fondé sur les données les plus récentes de Statistique Canada et offre pour la première fois une interface utilisateur interactive Excel qui facilite la saisie des données et l'étude des sorties.

Limites

Comme dans le cas de tous les modèles d'entrées-sorties, la version 4.1 accuse d'importantes limites. La première découle du fait que les données publiques de Statistique Canada datent de trois à cinq ans et qu'elles sont en partie censurées pour des raisons de confidentialité. Une deuxième limite est attribuable à la nature statique du modèle. En effet, s'il est vrai que les modèles d'entrées-sorties peuvent définir l'incidence économique en quantifiant les emplois et le rendement (en dollars), ils ne renseignement aucunement sur la dynamique de l'incidence. Autrement dit, la période au cours de laquelle s'exercerait l'incidence ainsi que les effets secondaires ne sont pas connus même si les répercussions sur d'autres industries sont modélisées à l'aide de simples suppositions.

Le modèle de Leontief implique par ailleurs la linéarité des facteurs de production, c'est-à-dire la proportionnalité constante des intrants et des extrants. Aussi le modèle ne tient-il pas compte des progrès technologiques ni des éventuelles économies d'échelle.

Enfin, les modèles d'entrées-sorties n'expliquent pas précisément les variations du comportement des consommateurs. Dans un contexte de récession, par exemple, les ménages pourraient être plus portés à épargner ou à substituer un produit à un autre pour s'adapter à l'évolution des prix.

Conclusion

Malgré ses limites, le modèle 4.1 offre une interface interactive facile à utiliser pour exécuter des simulations et comparer l'incidence de différentes décisions de dépenses du MDN. Par l'exploration de scénarios, le modèle 4.1 donne aux employés d'autres services que le CARO un moyen d'améliorer la qualité générale de l'évaluation de l'incidence du MDN. La version 4.1 du modèle d'entrées-sorties est également un outil que les spécialistes de la recherche opérationnelle pourront utiliser dans de futures études de l'incidence économique.

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1 Introduction

Context

The Department of National Defence (DND) spends over $10 billion/year on goods and services mostly purchased from Canadian suppliers. The economic activity in Canada generated by the purchase is generally assessed through Input-Output (I-O) models developed by Statistics Canada (National I-O models).

Although Statistics Canada I-O models can be used to assess the impact of DND expenditures on the Canadian economy, they provide only an indistinct assessment of DND spending impact due to the military/specialized nature of some of the goods and services purchased.

The Defence Economics Team at the Defence Research and Development Canada Centre for Operational Research and Analysis (DRDC CORA) was tasked (Weldon (2011)) to develop a tailored Input-Output (I-O) Model based on Statistics Canada's (SC) data. The model developed by the Defence Economics Team highlights the military-industrial sector by aggregating the SC data which is less relevant to DND staff and providing details of the industrial sectors and commodities related to DND activities. By doing so, the model provides a way to improve the quality of impact assessment of DND spending on the Canadian economy. The new model also allows DND staff, such as Director Strategic Finance and Costing (DSFC), to run simulations to assess the domestic impact of decisions on major equipment purchases.

History

The in-house production of an I-O model based on SC tables and matrices began in the 1980s with Lebreton's work on base closure assessments (Lebreton (1985) and Lebreton (1987)) and ended with his departure in the late 1980s. The re-establishment of the new economics team in the Directorate of Social and Economic Analysis (DSEA) revived the I-O tradition with formal in-house modeling labeled the DND Input-Output Model (DIO 2.1) in 1992 with an update in 1995, the DIO version 3.1. The latter version introduced partial closure of the model to household consumption (Solomon (1992) and Solomon (1995))[1] The 1995 version also used SC data based on the 1992 Canadian economy and industrial relations. A lag of 3-4 years is an unfortunate drawback of I-O models as the collection, analysis and integrity checks tend to be both labour and time intensive. Since the transfer of the DSEA activities to the finance group in DND in 1996, the I-O model was not updated.

After 1996, DND relied on consultants such as the Conference Board of Canada and KPMG to conduct socio-economic studies on military installations and used the multipliers from such studies to respond to additional inquiries (KPMG (2000)).

With this project, DRDC CORA's new Defence Economics Team revived the I-O model with a new user-friendly interface built using Microsoft Excel. Because of memory limita-

[1] The concept of open and closed versions of the I-O model will be discussed in subsequent sections.

tions in previous versions of Excel, the last version of the DND I-O model had been coded in C and was run as an executable programme under MS DOS using the command prompt. All outputs were produced at once and stored in a long text file. The new tool is designed to be more interactive in order to allow DND staff to run simulations and easily explore the results. In addition, the latest SC data was used in the construction of the new model providing a better representation of defence industrial sectors and commodities and their interrelationships. The latest data represents the Canadian economy in 2006.

Rationale for developing in-house I-O models

The rationale for using economic impact assessment tools and models stems from the continued popularity of framing defence expenditures within the context of the Canadian macroeconomy. Given DND's extensive presence in several regions of Canada, impact assessment documents remain an important source of public relations for the Department of National Defence (DND) and a lobbying tool for local politicians. Parai (1991) also points out that the establishment of an economics team within DND in the early 1990s was to satisfy the perceived need for an economic analysis of the impact of defence on the Canadian economy and to a lesser extent to analyze the consequences of changes in the Canadian economy on DND and Canadian Forces (CF) expenditures. Another popular application of economics and I-O models is the assessment of the interrelationship between industry and defence as well as defence readiness and employment.

While the above arguments point to the need for impact assessments, they do not provide rationale for developing an I-O model in-house. Technically speaking, Statistics Canada (SC) and economic think tanks such as the Conference Board of Canada (CBoC) can perform the impact assessment at roughly $1000 per simulation at the national level and at about $10,000 for provincial simulations. Unfortunately, demand for impact assessments in DND are frequent and time sensitive (Lebreton (1985)). These aspects make them fairly expensive and susceptible to the schedules and availability of these outside sources. In addition, the assessments of certain procurement programmes or military installations can be sensitive from security and political perspectives (Solomon (1995)). Finally, the SC I-O data needed to be modified to better reflect the defence industrial sectors and commodities (Solomon and Fegan, 2Lt S. (1993)).

Structure of the report

The rest of the paper is structured as follows. The next chapter reviews the economic and foundations of input-output models as well as their limitations and alternatives. Chapter three presents the mathematical formulation of the new DND I-O model, DIO Version 4.1, and calculations. Chapter four provides a brief tutorial on how to run the model and interpret results. Finally conclusions and recommendations can be found in Chapter five.

2 Input-Output Models

2.1 Motivation and purpose

In general, I-O models are accounting tools designed to track interindustry relationships and regional flows of production. As such, I-O models can be used to estimate the economic impacts of a defence project or government programme on the national or local economy. I-O models can also quantify the impacts of such projects on value-added components such as wages and profits and can estimate the import content and job creation potential. In order to perform calculations in a meaningful way, I-O models typically require a large amount of economic data and a high level of precision.

The various outputs of the DND I-O model illustrate the way in which defence expenditures affect different sectors of the Canadian economy either directly or indirectly, in terms of revenues and job creation potential.

The following section provides a description of the economic data required in order to run the DND I-O model. It is followed by an overview of the model calculations and a discussion of the principal limitations of the DND I-O model.

User Guides published for previous iterations of DND I-O models, such as Lebreton (1985) and Treddenick (1983), can be consulted for an extensive summary of input-output models and a more general discussion of their strength and limitations in providing reasonable estimates of economic impacts.

2.2 Data requirements

In order to estimate economic impacts of defence expenditures, macroeconomic parameters describing the Canadian economy are required. This includes trade and employment data as well as detailed accounts of industry production factors, and variables such as exports, imports and consumption factors. This information is compiled by Statistics Canada (SC) and presented in a number of different formats characterized by different levels of aggregation into commodities and industries.

The main data for the DND I-O model is produced by SC's Industry Accounts Division (IAD) and presented in three tables.

This first table, called the Input table or Usage table, provides the intermediate and primary inputs required to produce a given product. For example, a vehicle will require intermediate inputs (products already produced by other sectors) such as tires or steel, as well as primary or factor inputs such as wages and salaries.

The second table, called the Output table of Make table, details the production of each industry. For example, the motor vehicles industry produces cars, vans, etc... If the industry is vertically integrated and produces parts and accessories, then the industry will also be shown to produce tires, car paints, etc... If the intermediate products are outsourced then the industry is only shown to produce the final product.

The third and last table, called the Final demand table, shows the economic activities of the different agents of the economy (households, firms and governments). Overall, the table details expenditures by consumers, construction and other business investments and governments as well as changes in inventory levels and international trade[2]. All figures are in current year dollars and producers' prices. The latter implies that the prices are at the factory gate and exclude margins such as transportation, retail, wholesale and indirect taxes.

Because of the high level of detail represented in SC's input tables, confidentiality issues can arise, especially for sectors and industries with sparse data (i.e. for instance when a sector is made of only a few companies). In order to protect private data, SC publishes data on industries and commodities in various levels of aggregation. The levels of data aggregation available at the time of building the new DND I-O model are shown in Table 1.

Table 1: Statistics Canada Input-Output table aggregation levels

Aggregation Level	**Number of Industries**	**Number of Commodities**
Worksheet (W)	309	727
Worksheet Public (WP)	285	713
Link (L)	117	469
Medium (M)	62	111
Small (S)	25	59

The Small (S) and Medium (M) levels of aggregations have the fewest amount of data suppressed for confidentiality purposes and are also available publicly. The Link (L) level is the level of aggregation used to make a time series of I-O tables that are linked historically to trace changes in industry and commodity classifications. This level of aggregation does contain several suppressed entries. The Worksheet Public (WP) aggregation level, with 285 industries and 713 commodities, is used for the version of the I-O model used in DND and, needless to say, is heavily censored. The level of detail provided by the WP aggregation level however provides the necessary amount of fidelity to conduct detailed impact assessments.

A more precise implication of the suppression of some data is that the I-O tables are not balanced, in other words supply does not equal demand (for some commodities the gap between supply and demand is as much as 94%). The rounding of data also adds to the imbalance as entries that are less than $500,000 are rounded down to zero. The solution to the problem is to use dummy industries and commodities to balance the tables. Information from the higher levels of aggregation (Link and Medium) has also been used to discern

[2]More specifically the categories of expenditures include domestic personal expenditures by residents and non-residents; personal expenditures by residents abroad (i.e. travel imports); personal expenditures by non-residents (i.e. travel exports (< 0)); current expenditures by level of government; capital expenditures by industry; scrap metal (< 0); inventory additions and withdrawals (< 0) by type of inventory; exports; re-exports (imported items sold to other nations without modification); imports (< 0). See Ghanem (2010) for a discussion of the different types of expenditures.

production patterns and to distribute dummy variables accordingly. The complete mathematical technique of balancing the tables requires working simultaneously in commodity and industry space as outlined in Dumas (1993).

After rebalancing, the three tables discussed above provide a representation of the Canadian economy that is used as the basis for the I-O model calculations.

2.3 I-O model calculations

The I-O model calculates the direct and indirect output for the different industrial sectors of the Canadian economy of a vector of defence expenditures, expressed in terms of a standard list of 713 commodities. This is done by considering factors such as margins, leakages and interindustry relationship, using the data provided by SC and described above.

Before introducing calculations, some of the model assumptions must be stated. I-O models are based on the Leontief's production function (Leontief (1951)) and as a result have the following key assumptions:

1. Inputs are demanded in fixed proportion to their outputs. As an illustration, consider the situation where two shovels are required for two labourers to dig a ditch. The addition of inputs (either shovels or labourers) in this case will result in unused inputs.
2. Inputs or factors of productions are available to the extent required.
3. Demand for domestically produced commodities is distributed among industries based on fixed market shares.

Following is an explanation of the sequence of calculations in I-O models in general and in DIO 4.1 in particular. The mathematical formulation of the model's calculations can be found in the following chapter.

Extraction and redistribution of margins

Since the impact analysis is based on what DND spends, the expenditures are necessarily expressed in purchasers' price. That is, the margins associated with trade, transportation and indirect taxes are included in DND expenditures. The SC data on the other hand considers producer's prices. In order to convert the DND expenditure data from purchaser's prices to producer's prices, margins need to be removed. There are eight margins corresponding to eight different commodity codes considered in the I-O model:

- trade margins for retail,
- wholesale trade margins,
- storage,

- indirect tax,
- pipeline for gas,
- pipeline for oil,
- gas distribution, and
- gas transportation.

The proportion of the prices attributed to each of the margins are called the margin ratios and are calculated based on SC data on margins and removed from the DND expenditures. The total of the removed margins is re-distributed to the corresponding commodity code. Thus, the total expenditures in the model are the same before and after the margin removal. The outcome of this step is a new expenditures vector expressed in producer's prices and compatible with SC's I-O tables.

Accounting for economic leakages

Some activities are considered to be outside the normal flow of domestic economic activity and must be considered when accounting for consumption patterns. These activities, which include imports, inventory withdrawals and scrap metal, are 'leaked' from the economy. The I-O model accounts for leakages by removing a 'leakage' factor from the DND expenditures vector. The leakage ratio, or the proportion of the expenditures that is 'leaked' out of the economy, is defined for each commodity code using data provided by SC. The leakage ratios are based on producers' prices and so it is critical that the leakage factor be considered after removing the margins so that the ratios are applied to producer prices rather than purchaser prices.

For DND impact assessment, scrap metal and inventory withdrawals are not explicitly removed since it is difficult to ascertain what portion of future or present DND expenditure is due to inventory withdrawal. In addition, it is unlikely that DND will be using scrap metal for its requirements. However, about 10% of DND's expenditures is imported and this information is explicitly incorporated in DND's I-O model.

Note that in previous iterations of both SC and DND I-O models, the government sector was considered outside of normal economic activity. With the adoption of the international standards on income accounts in the early 1990s, (IMF (1993)), SC incorporated the government sector by adding the goods and services bought and sold by all levels of government.

Estimating direct and indirect economic impacts

Money spent by DND has a ripple effect on the Canadian economy. The industries directly affected by DND expenditures increase their output which in turn leads to increased activity for other industries. The I-O model makes the distinction between the impact on industries directly affected by DND spending, or direct impact, and the additional impact on industries

which are interconnected with the industries directly affected by DND spending. The latter is called the indirect impact and in the DND I-O model also includes the direct impact.

Two important matrices are necessary to complete the estimation of the economic impact of DND expenditures on the Canadian economy. These two matrices, the Direct Impact Matrix and the Indirect Impact Matrix, are constructed using the data provided by SC in the three input tables discussed earlier.

The Direct Impact Matrix has 713 rows for commodities and 104 columns for industries and represents the market share of each industry. The matrix represents the proportion of a given commodity produced by a specific industry.

The Indirect Impact Matrix (713 commodities by 104 industries) is obtained by multiplying the Direct Impact Matrix (713 commodities by 104 industries) by a matrix of Industry interrelationships (104 industries by 104 industries) and represents the final output for an industry resulting from DND expenditures after considering the spill-over effects of one industry into another. These spill-over effects are modeled by the Industry interrelationship matrix, also provided by SC.

The derivation of the impact matrices is discussed in many standard texts such as Leontief (1951), but for a discussion that is more specific to SC I-O impact matrices see Mercier et al. (1991) and Hoffman and al. (1980).

Calculating economic impact by industry

The multiplication of the Direct Impact Matrix by the vector of DND expenditures, after removal of margins and leakages, gives the output by industry. In other words, the direct output for an industry is the sum of DND expenditures in the different commodities multiplied by the market share of the industry for these commodities. The direct output by industry shows the specific industries that are initially affected by DND's purchases of goods and services.

Similarly multiplying the corrected vector of DND expenditures by the Indirect Impact Matrix gives the indirect output by industry. Note that the indirect impact matrix also include the direct impact and as such, can be considered as the total impact matrix.

Finally SC also provides as part of the I-O package a vector of job-output ratios which indicate the potential job creation per unit of output for each industry. Multiplying the direct output for each industry, calculated previously, by the associated job-output ratio provides an estimate of the potential number of jobs created for each industrial sector as a result of DND expenditures. The indirect potential for job creation is calculated similarly by multiplying the indirect output by the job-output ratios.

Note that the job-output ratios imply a linearity assumption, i.e. the first $100,000 of investment in an industry will create the same number of jobs an additional $100,000 further down the line in the same industry. This linearity assumption is necessary in order to have a model of an acceptable complexity, especially given the large number of industries and

commodities considered. This assumption is typical of input-output models. The section on I-O model limitations (section 2.4) discusses this aspect further.

Impact on primary inputs

I-O Models also calculate the impact of expenditures on "primary inputs". The primary inputs are included as commodities in the model but are treated differently than other commodities. They are considered as inputs only in subsequent rounds of economic impact and for this reason are expected to have a value of 0 in the original DND expenditure vector. They are also removed from the Impact matrices.

The primary inputs considered in the DND I-O model include:

- Indirect taxes on products,
- Subsidies on products,
- Other subsidies on production,
- Other indirect taxes on production,
- Wages and salaries,
- Supplementary labour income,
- Mixed income, and
- Other operating surplus.

The impact on primary inputs is calculated by multiplying the output by industry (calculated previously) by the primary coefficients, provided by SC. Primary coefficients represent the amount of each primary input that would result from one additional unit of production, for each industry. The calculation of the impact on primary inputs is called "Income Account Summary" in the DND I-O model.

Closed I-O Model - Consumer induced impact calculation

There is a likelihood that additional spin-off activity can be generated as a result of the DND expenditures. This includes for example employees of industries that are affected both directly and indirectly consuming a portion of their wages on consumer goods and services. Additional spin-off can also take the form of investments by firms and individuals in other businesses supporting military activities such as military museums or schools and programmes for military children and spouses.

The latter is difficult to model but can be determined after the fact by looking at industrial clusters. The former can be estimated by 'shocking' the I-O model with personal consumption patterns derived from the Final Demand table. In other words, personal consumption patterns can be treated as a new expenditure vector and the I-O model calculations applied

to estimate their economic impact. The calculation of consumer induced impact is included in this version of the DND I-O model.

The *partial closure adjustment routine* starts by summing the wages and salaries component from the income account summary. This sum is then multiplied by a vector of personal expenditures in commodity space. This new vector is then treated as any expenditure vector and the necessary adjustments via margins and leakages are performed. A new round of industrial production, employment and income account summary are then calculated and the loop continues until the wage and salary components reach close to zero (there is also a mathematical short-cut to optimize on the loop of expenditures).

The consumer induced impact calculations have some methodological limitations. First, this type of partial closure favours labour-intensive industries and understates capital-intensive production. Specifically, any additional demand on an industry's output does not necessarily imply an increase in labour input, it may just employ more machinery instead. In fact an increase in labour does not tell us whether the additional labour will be satisfied by new labour from outside the industry, or by redirecting of labour from idle sectors within the industry. Secondly, the consumption pattern used for the simulation is the average of all Canadians at a given year. However, applying the average consumption pattern may distort results if the military installation or DND expenditure is targeted at a community or sector with higher (lower) income than the average Canadian income. Thirdly, any additional impact that may result by employing profits into R&D or the financial sector is overlooked. Finally, the I-O model is static and as such tends to be silent on the duration of the impact, and on the stage of the business cycle during which the impact is concentrated. Consumers' behavior however is likely to be dependent on the evolution of the economy. For instance, during recessions consumers' propensity to save tends to increase substantially and consequently any additional income earned by the household will be leaked out of the economy as savings. Thus the multiplier effect of expenditures during recession is much lower.

The following section discusses other limitations of I-O models in general.

2.4 I-O models limitations and alternatives

In addition to the limitations already mentioned throughout the discussion of the model calculations, there are a number of other limitations that result from the model's underlying assumptions.

The first assumption constrains technological progress and industry's need to continuously adjust its input requirements and sourcing. These aspects also relate to the third assumption of fixed market shares as new entrants into markets and mergers affect market shares. If the economy is in full employment or if a particular skill set is in high demand, the second assumption is misleading since it fails to show how and where the resources are re-allocated, the implications of economies of scale, or any supply constraints. In addition, the impact on the general price level is also ignored (Treddenick (1983)). Economic analysis is also about studying economic agents and here I-O models also fail to incorporate economic behaviour by agents in response to variations in prices.

These limitations can be mitigated by combining other economic models that emphasize dynamics or the behaviour of economic agents. For example, the Computable General Equilibrium (CGE) model (Treddenick (1983)) is a mirror opposite of I-O models in its assumption of input resources and price signals. Specifically, CGE models assume that factor products are fully employed and any demand shock (expenditures in consumption or investment) will result in labour and capital being re-allocated in response to price changes. While CGE is loosely based on the classic economic concept of general equilibrium and constrained profit maximization, relative price change is the key variable that drives and re-equilibrates the model.

Another alternative is a more elaborate simultaneous equation model of Canada in order to capture the dynamics of economic shocks, the intermediate processes and the duration of the shock on the Canadian economy. Another variation in the study of temporal effects is system dynamics. While heavily mathematical in the tradition of engineering and feedback control systems, system dynamics is an ideal tool for systems characterized by interdependence and information feedback. In a resource rich environment, running multiple models will get one closer to approximating reality, but in a resource constrained environment, choices are inevitable. An I-O model with modifications is one such choice that is employed here. For readers interested in the alternate models discussed above Shoven and Whalley (1984) is the authoritative text on CGE models in general and their application in trade theory in particular. Macroeconomic modeling is surveyed extensively by Côté et al. (2003) and an application and basics of system dynamics is discussed in Desai and Taylor (2007).

Finally, the focus on quantifiable impacts must be cited as another form of limitation of the I-O models. While there may be social and psychological impacts due to defence expenditures (communities identifying with local industries and military installations or the sense of security of a stable employer, for instance), an analytical model such as the I-O model only considers those impacts (usually economic) that are most readily estimated.

The use of I-O models in DND and elsewhere is rather pragmatic. I-O models have a more disaggregated view of industries than other economic models such as CGE or macro econometric models. This detailed view of industries provides policy relevant information. For example, which sectors of the economy are dependent on defence expenditures and how much of the economic activity generated by defence spending is locally or internationally sourced?

Which model is more realistic depends on the expectations of producers and labour on the economic shock; for example, the effect of a defence budget cut or a base closure. That is, if they assume the cuts are transitory or they anticipate other regions are not as attractive, they will remain in the region; alternatively, if the cuts are seen as permanent then both labour and capital may migrate outside the region.

Sub-National Level Impacts

The I-O model described here is based on nationally aggregated information, however I-O

models can also have regional dimensions. SC publishes provincial level tables, albeit, at a smaller aggregation to preserve confidentiality. Sub-national, in particular sub-provincial, data would be ideal for DND to assess economic impacts of military installations on local economies. However, the detailed information required and the confidentiality restrictions constrains building such models. Consequently, some heroic assumptions and approximations from alternative approaches and Census data have to be utilized to estimate community-level impacts.

The Strategic Finance and Costing section in DND publishes annual estimates of defence expenditures by province and electoral districts (Department of National Defence (2009)). This publication provides a very good approximation of the direct economic impact on local and provincial economies. The total impact and other economic spin-offs can be calculated using multipliers and other methodological short-cuts. As such, there is no need for the development of in-house provincial or sub-provincial level I-O models. Parai et al. (1996) provide a good summary of a methodological short-cut relying on community level data and interprovincial trade flow information. In general the hybrid model uses data from military installations such as operations and maintenance expenditures, wages and salaries data detailed by postal code or by city. The data is then verified for consistency by comparing it to headquarters level administrative data. Margins are extracted for goods that are retailed but not locally produced, using margins and trade flow data from SC. Trade flow data are used to provide information on provincial demand for goods and services and to determine the proportion of the demand that is satisfied locally (provincial self-sustainment). For operations and maintenance expenditures, expenditure by commodity is multiplied by the corresponding coefficient of provincial self-sustainment to estimate the direct impact. The remaining income, after adjusting for national and provincial taxes and capital component, is multiplied by the appropriate family expenditure ratios (for the province) as well as by the coefficients from the trade flow data to estimate the indirect impact.

The direct impact from wages and salaries of military and civilian personnel in local bases is extracted from the DND estimates discussed earlier and can be adjusted using trade flow data from SC. Induced impacts (consumption-induced) are estimated by adjusting incomes for local and national tax and other leakages [3]. Census data is also valuable for modeling sub-provincial economic impacts. However, detailed data is only available every few (5) years. During this gap the estimates from DND and multipliers can be used.

Please note that the current version of the DND I-O model calculates total jobs. That is, it includes full-time, part-time and/or temporary jobs.

[3]For example, from family expenditure data we know that 15.3% of a family's income is spent on food and that the province satisfies 61% of local demand. If gross wages are $100, then $15.30 out of $100 is spent on food ($100*15.3%), of which $9.33 remains in the community ($15.3*61%).

3 Mathematical formulation

The objective of the calculations of the I-O model is to determine the impact of DND expenditures on the different industries that make up the Canadian economy. The present chapter details the formulas used in the model.

First it is assumed that the economy consists of N industries using C different commodities as inputs and outputs. The DND expenditure vector is expressed as $\boldsymbol{E} = [e_1, \ldots, e_C]$.

The calculation of economic impact is based on the simple equation of the balance between production inputs and outputs. Considering the output o_j of industry j, this can be expressed as follows:

$$o_j = \sum_i (s_{ij} \times x_i),$$

where x_i is the available input in terms of commodity i, and s_{ij} is the share of input i required to produce one unit of output for industry j.

The vector of available inputs $\boldsymbol{X}$ is derived from the vector of DND expenditures $\boldsymbol{E}$ by removing the necessary margins and leakages. This operation, detailed in the next section, converts amounts from purchaser's to producer's prices.

Redistribution of margins

The eight margins considered in DIO 4.1 are first removed from each of the N commodities. The list of margins can be found in Annex C. The i^{th} component of the new expenditures vector $\boldsymbol{X}$ is given by:

$$x_i = e_i \times \sum_k (1 - \mu_i^k),$$

with μ_i^k the ratio of commodity i that goes to the k^{th} margin.

In order to maintain balance, the sum of the margins removed are added back to the expenditures vector but redistributed to the commodities which represent the different margins, i.e. the total of the retail margins removed from all commodities is added to a commodity called 'retail margin'. The expenditure vector $\boldsymbol{X}$ is updated to account for the redistribution of the k^{th} margin into the corresponding commodity M_k as follows:

$$x_{M_k} = x_{M_k} + \sum_i (\mu_i^k \times e_i),$$

where x_{M_k} is the expenditure for the commodity M_k representing the k^{th} margin.

In addition, the transport margin is further divided into seven sub-margins. A similar procedure is applied to redistribute the transport sub-margins. Calling T the index of the

commodity representing the transport margin and t_1 to t_7 the indices of the commodities representing the transport sub-margins, we can write:

$$x_{t_k} = x_{t_k} + (x_T \times \rho^k),$$

with ρ^k the coefficient of redistribution of the transport sub-margins ($\sum_{k=1:7} \rho^k = 1$). The redistribution coefficients are provided by SC.

After the redistribution of the transport margin to the transport sub-margins, x_T is set to 0 since it has been entirely redistributed.

The resulting final vector $\boldsymbol{X}$ represents DND expenditures after removing margins. From hereon mentions of 'the vector of DND expenditures' refer to $\boldsymbol{X}$ and not to the original vector $\boldsymbol{E}$ which was expressed in purchaser prices.

Accounting for economic leakages

SC provides a leakage ratio $\Lambda = [\lambda_1, \ldots, \lambda_C]$ for each of the commodities. The ratio represents the proportion of the expenditures that are not part of regular economic activities (see previous Chapter for a discussion of the concept of leakage).

The vector of expenditures $\boldsymbol{X} = [x_1, \ldots, x_C]$ is converted into a new vector $\boldsymbol{Y} = [y_1, \ldots, y_C]$ by removing the leakage factor Λ. The components of $\boldsymbol{Y}$ are given by:

$$y_i = x_i \times (1 - \lambda_i).$$

Calculating output by industry

The direct output $\boldsymbol{O} = [o_1, \ldots, o_N]$ is calculated by multiplying the corrected expenditure vector $\boldsymbol{Y}$ by the Direct Impact matrix $\boldsymbol{M}$. This can be expressed by:

$$o_j = \sum_i (y_i \times m_{ij}).$$

The Direct Impact matrix $\boldsymbol{M} = [m_{ij}]_{i=1,\ldots,C, j=1,\ldots,N}$ indicates the share of commodity i produced by industry j.

Multiplying the Direct Impact matrix $\boldsymbol{M}$ by the matrix of interindustry relationships $\boldsymbol{R}$ creates the Indirect Impact matrix $\boldsymbol{M'}$ [4]. The interindustry relationship matrix $\boldsymbol{R} = [r_{j_1 j_2}]_{N \times N}$ states the amount of output from industry j_1 that is required to produce one unit of output in industry j_2.

[4] The prime symbol (') is used here to denote variables that are related, such as the Direct Impact matrix $\boldsymbol{M}$ and the Indirect Impact matrix $\boldsymbol{M'}$ or the Direct output $\boldsymbol{O}$ and Indirect output $\boldsymbol{O'}$. This notation is used for ease of presentation and should not be confused with some other mathematical usage such as the notation of derivatives, transposed matrices or set complements.

The indirect output can be calculated by multiplying the corrected expenditure vector $\boldsymbol{Y}$ by the Indirect Impact matrix $\boldsymbol{M'}$:

$$o'_j = \sum_i (y_i \times m'_{ij}).$$

Job creation potential

The calculation of the job creation potential $\boldsymbol{Q} = [q_1, \ldots, q_N]$, expressed as a number of jobs, is simply obtained by multiplying the output by industry $\boldsymbol{O}$ by an estimate of the number of jobs that would be created by the addition of one unit of output in the industry. The latter is called the job-output ratio per industry and noted $\boldsymbol{Z} = [z_1, \ldots, z_N]$, it is provided by SC. Hence, the number of jobs directly created for an industry j is given by:

$$q_j = o_j \times z_j.$$

Similarly, the number of jobs indirectly created is given by:

$$q'_j = o'_j \times z_j.$$

Impact on primary inputs

The last seven commodities considered in the model are called the primary inputs and are treated differently than the other commodities (see Annex C). The primary inputs account for such factors as taxes, subsidies, profits and wages and are not included in the Impact matrices[5]. Instead, for each industry, coefficients are provided indicating the fraction of each of the primary inputs required to produce one unit of output. The matrix of primary coefficients can be defined by $\boldsymbol{H} = [\eta_j^k]_{j=1,\ldots,N,k=1,\ldots,7}$. We can calculate the direct impact $\boldsymbol{P}$ on primary input k by summing the products of the output by industry by the corresponding primary coefficient:

$$p_k = \sum_j (\eta_j^k \times o_j).$$

For the indirect impact,

$$p'_k = \sum_j (\eta_j^k \times o'_j).$$

[5]The lines corresponding to these commodities are zero'd out in the Impact matrices

Consumer induced impact

As explained in the previous section, a share of the wages and salaries resulting from the new DND expenditure may be redirected to the economy, for example as household expenditures. The share of wages and salaries that is spent as household expenditures on each commodity is expressed as the household expenditure ratio for this commodity.

Defining h_i as the household expenditure ratio for commodity i, ($\sum_i h_i = 1$), we can calculate a new expenditure vector representing consumer expenditures:

$$x_i^{(2)} = P_5 \times h_i \times 0.7,$$

with P_5 the fifth primary input representing the wages and salaries resulting from the DND expenditure vector $\boldsymbol{X}$. The factor 0.7 is used to convert from gross to net wages and salaries by considering an average tax rate of 30% for Canadian households. The superscript (2) is used to indicate the new 'round' of calculations which represents secondary effects on the economy.

The vector of expenditures $\boldsymbol{X}^{(2)}$ can be corrected by removing margins and leakages in the same way as above, resulting in a new expenditure vector $\boldsymbol{Y}^{(2)}$.

As previously, we can calculate direct and indirect economic output as follows:

$$o_j^{(2)} = \sum_i (y_i^{(2)} \times m_{ij}),$$

$$o_j'^{(2)} = \sum_i (y_i^{(2)} \times m'_{ij}).$$

Similarly, direct and indirect job creation potential can be calculated by:

$$q_j^{(2)} = o_j^{(2)} \times z_j,$$

$$q_j'^{(2)} = o_j'^{(2)} \times z_j \ .$$

The impact on primary inputs for this new round can also be calculated as previously:

$$P_k^{(2)} = \sum_j (\eta_j^k \times o_j^{(2)}),$$

$$P_k'^{(2)} = \sum_j (\eta_j^k \times o_j'^{(2)}).$$

In particular, the new impact on wages and salaries is given by $P_5^{(2)}$. For simplicity we can rename the wages and salaries from the two iterations:

$$ws_1 = P_5, \text{ and}$$

$$ws_2 = P_5^{(2)}.$$

In order to calculate the total impact, the iterations would need to be repeated until the wages and salaries reach 0, i.e. when there is no longer any impact in the economy of the original DND expenditure. In order to simplify calculations, a Consumer Induced Multiplier (CIM) is derived from the first two rounds and used to estimate the final impact of subsequent iterations without running the entire simulation repeatedly.

The CIM is a mathematical shortcut for estimating the total impact on the economy of the expenditure shock (DND expenditures), it is defined by:

$$CIM = \frac{1}{1-\frac{ws_{t+1}}{ws_t}},$$

where t is any iteration of the model. The value of CIM is expected to converge quickly as the number of iterations increase. In DIO, the outcome of the first two iterations are used to reduce the calculation load and the CIM is expressed as:

$$CIM = \frac{1}{1-\frac{ws_2}{ws_1}}.$$

Using the newly calculated multiplier, we derive the following relationships to describe the final impact of the expenditure shock on the economy after considering consumer induced impact.

Table 2: Consumer Induced Impact Calculations

Variable	**Formula**
CIM	$\frac{1}{(1-\frac{ws_{t+1}}{ws_t})}$
Total Consumer Induced Impact	$CIM \times \sum_j o_j^{(2)}$
Total jobs due to consumer expenditures	$CIM \times \sum_j q_j^{(2)}$
Total indirect taxes due to consumer expenditures	$CIM \times (P_1^{(2)} + P_2^{(2)} + P_3^{(2)} + P_4^{(2)}) \times \sum_j o_j^{(2)}$
Operating surplus and net business income due to consumer expenditure	$CIM \times (P_7^{(2)} + P_8^{(2)}) \times \sum_j o_j^{(2)}$

4 User Guide

DIO 4.1 Interface

The latest version of the DND Input-Output model is designed using Microsoft Excel and provides a straightforward and interactive interface for running simulations and exploring results.

All calculations are embedded in a single Excel workbook which is available upon request from the authors. Following is a short overview of the new model's interface.

The first spreadsheet of the Excel workbook (Figure 1) is an introductory page and contains instructions as well as links to all other pages (i.e. spreadsheets). All other pages of the workbook have hyperlinks to take the user back to the *Intro* page. The page can be used to navigate through the different sections of the workbook. The links are divided in three categories: *Inputs*, *Outputs* and *Data and parameters*. The user only needs to enter information in the Input pages. The Output pages hold all the results of the simulation and the *Data and parameters* pages contain the underlying data that is necessary to run the simulation. The last two sets of pages (*Output* and especially *Data and parameters*) should not be modified.

The Input-Output calculations are performed automatically whenever new data is entered. There is no command to start the simulation.

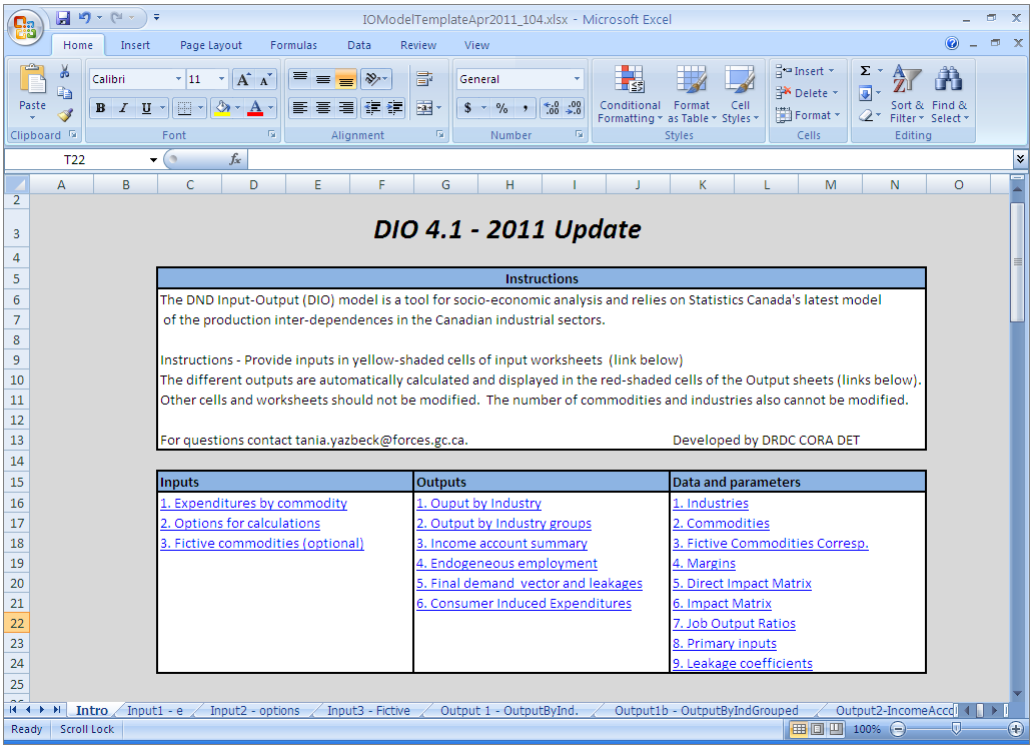


Figure 1: DIO 4.1 Introduction Page

Model Input Variables and Parameters

The *Input1-e* tab (Figure 2) can be opened by selecting the *Expenditures by commodity* link from the introduction page. This input page is where DND expenditures are entered. The blue cells contain the list of all 713 commodities considered in the model, corresponding expenditures must be entered in the yellow cells (in the column labeled *Expenditures (Million $)*). Commodities that are not part of DND expenditures should get an entry of 0 in the Expenditure column. As well a number of specific commodities[6], including the primary inputs, must be left at zero. Note that there is no verification embedded in the model and that data entered in the wrong format may lead to calculation errors later on. Also note that text can be entered anywhere in the spreadsheet for personal reminders or calculations.

Once data is entered, the user can click the link at the top right of the page to be directed back to the introduction page. From there the next input page can be selected.

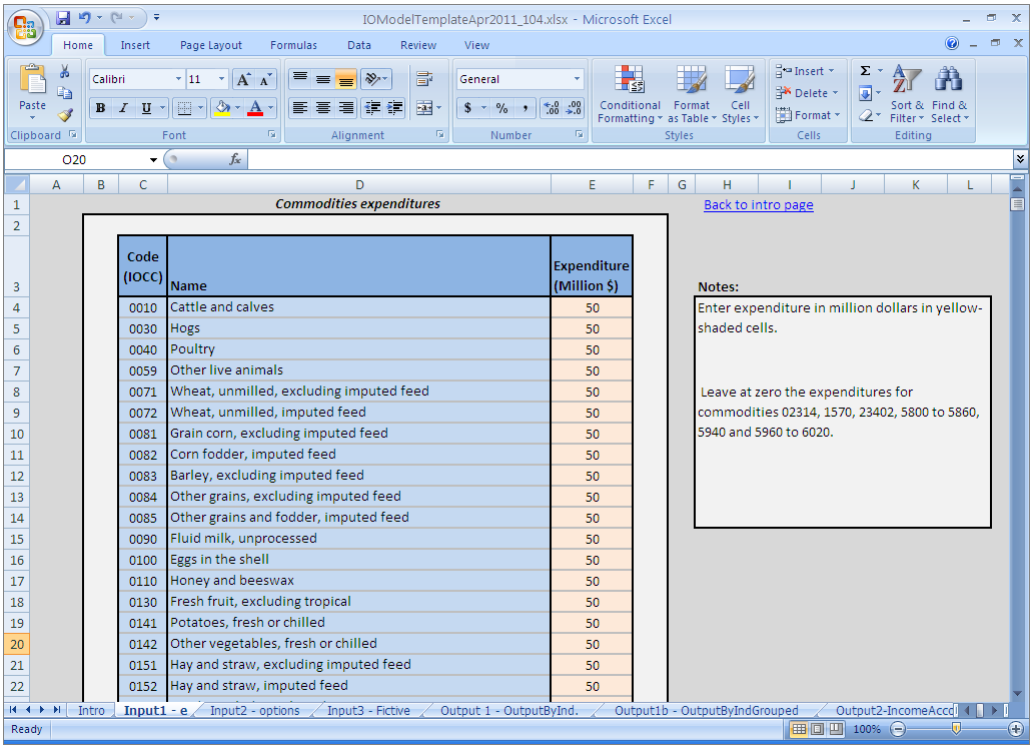


Figure 2: DIO 4.1 Screenshot - Entry of DND expenditures

The second input page (Figure 3) is accessed by selecting the second input link on the introduction page or by choosing the *Input2 - options* tab. The page provides the user with the choice between running a simulation of the impact on the domestic economy or a simulation of the impact on exports only. The selected option is entered by typing either *1* or *2* in the yellow-shaded cell of the table. By default, the domestic option is chosen

[6] As indicated in the spreadsheet these commodities are numbered 02314, 1570, 23402, 5800 to 5860, 5940 and 5960 to 6020.

however the last value entered will be saved upon quitting the programme. As with the previous page, once the input data is entered, the user can select the link at the top right corner of the page to go back to the introduction page and select the third and final input sheet.

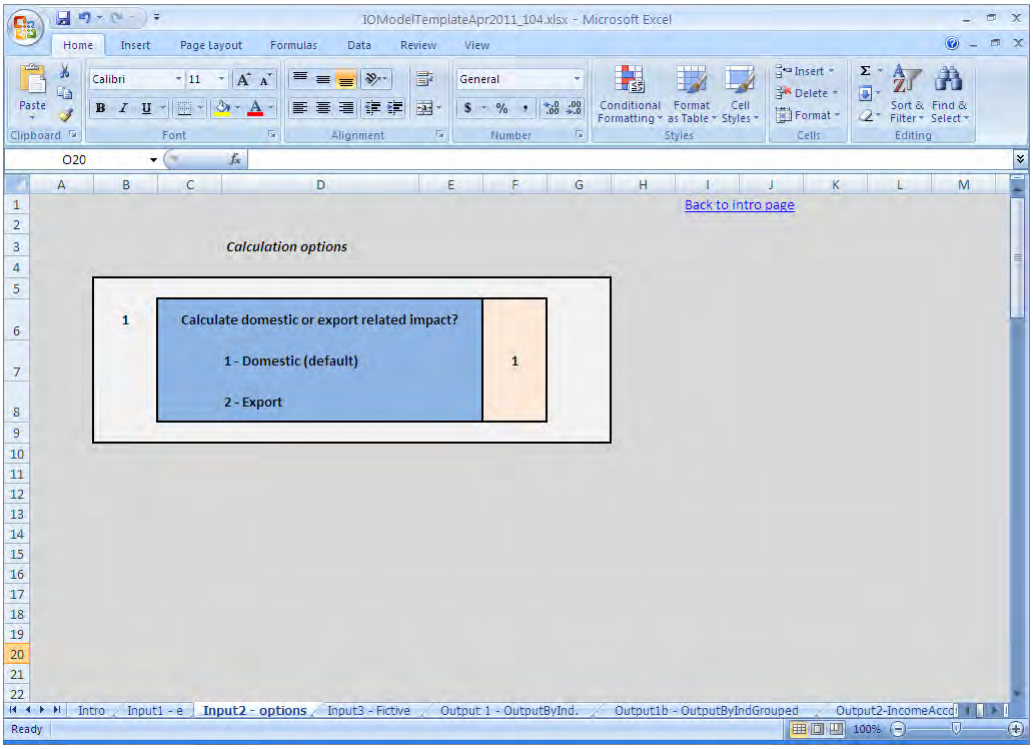


Figure 3: DIO 4.1 Screenshot - Choice of simulation option

The third input page (Figure 4) is optional. It has been created to allow the user to enter data for seven commodities that do not appear directly in the SC list of commodities. These 'fictive commodities' can be converted into the standard 713 commodities of the SC model using the table of correspondence that appears on this page [7]. This is done by entering values (in Million $) in the yellow-shaded row. The values appearing in the correspondence table represent the conversion of these fictive commodities into the standard list of commodities. The values must then be added manually to the first input table (table of DND expenditures, i.e. tab *Input1 - e*).

[7] Fictive commodities are created by Statistics Canada for accounting purposes to capture commodities which do not 'fit' into the list of standard commodities. This includes for instance commodities which are more generic such as 'laboratory supplies'. Through the fictive commodity table, SC creates a breakdown of the fictive commodities into the standard list of 713 commodities.

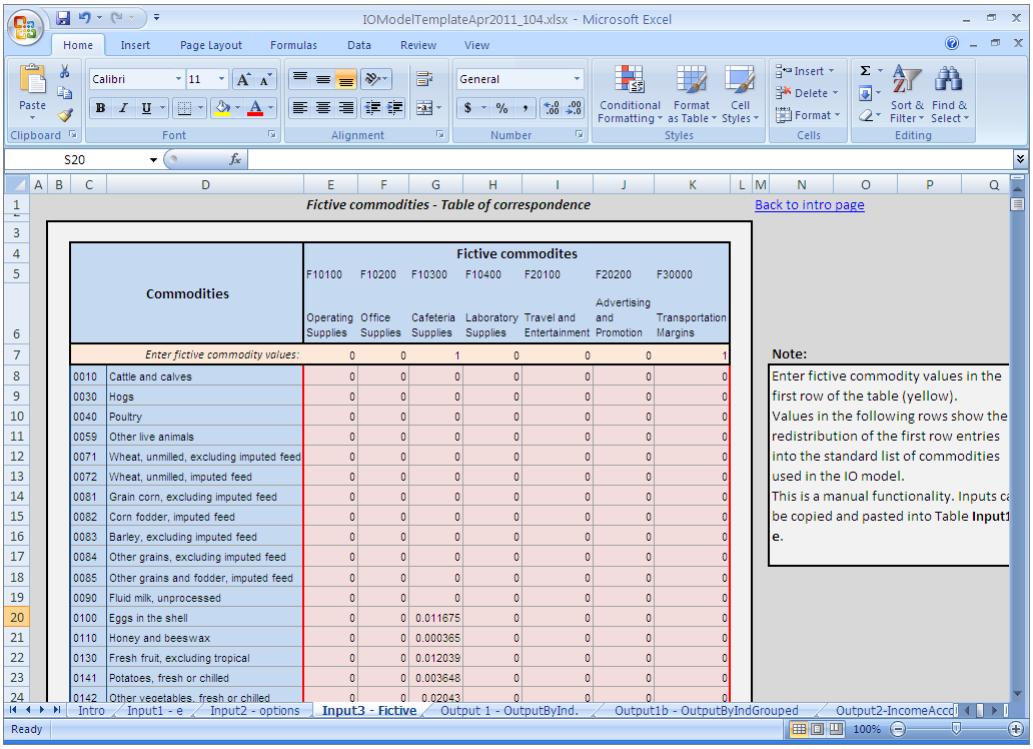


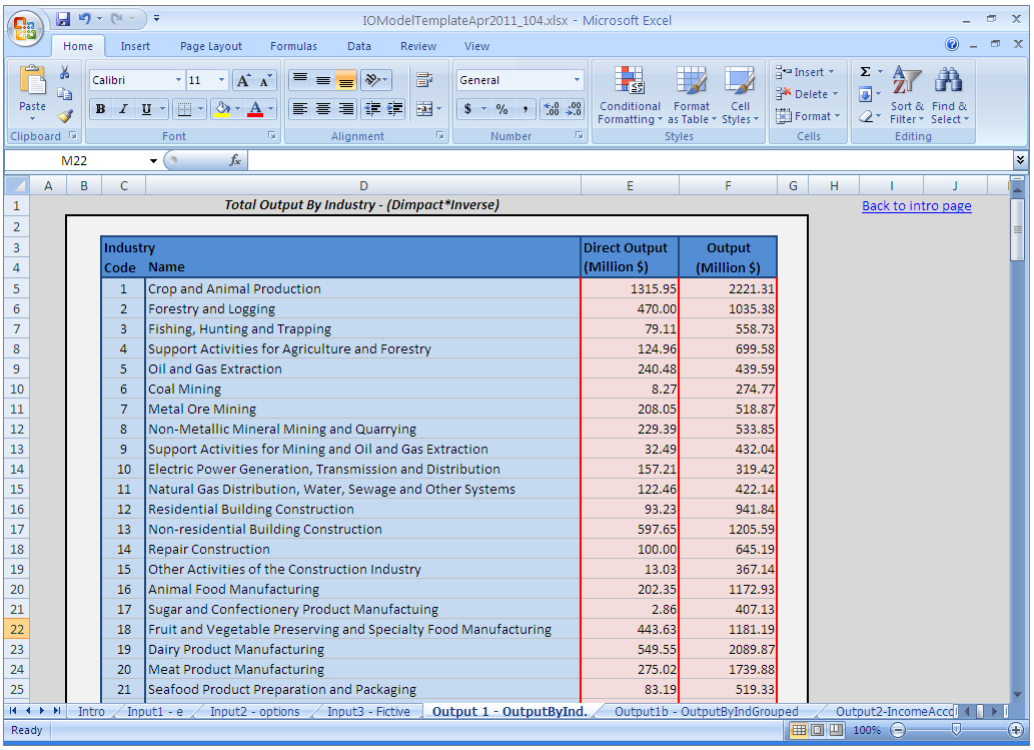
Figure 4: DIO 4.1 Screenshot - Fictive commodities

Model Outputs

The simulation outputs are updated as soon as the entries in the Input sheets are modified. The various outputs can be explored through six different output pages with links appearing on the introduction page.

The first of these output pages provides the *Output by industry* (Figure 5) and can be found by choosing the *Output1-OutputByInd* tab or the appropriate link on the introduction page. The second column of the table lists the 104 different industries considered in the model (the first column is simply an index for easy reference) and the last two columns show the direct and indirect output respectively, in Million $.

The following output page *Output by industry groups* (Figure 6) shows the same data as the previous page except that industries are grouped using three different levels of aggregation. The first table (SMALL) groups the industries into a small set of 22 categories. The second table, found below, shows a grouping of 22 categories that is more relevant to defence expenditures. The last group (MEDIUM) groups the industries into 59 categories.

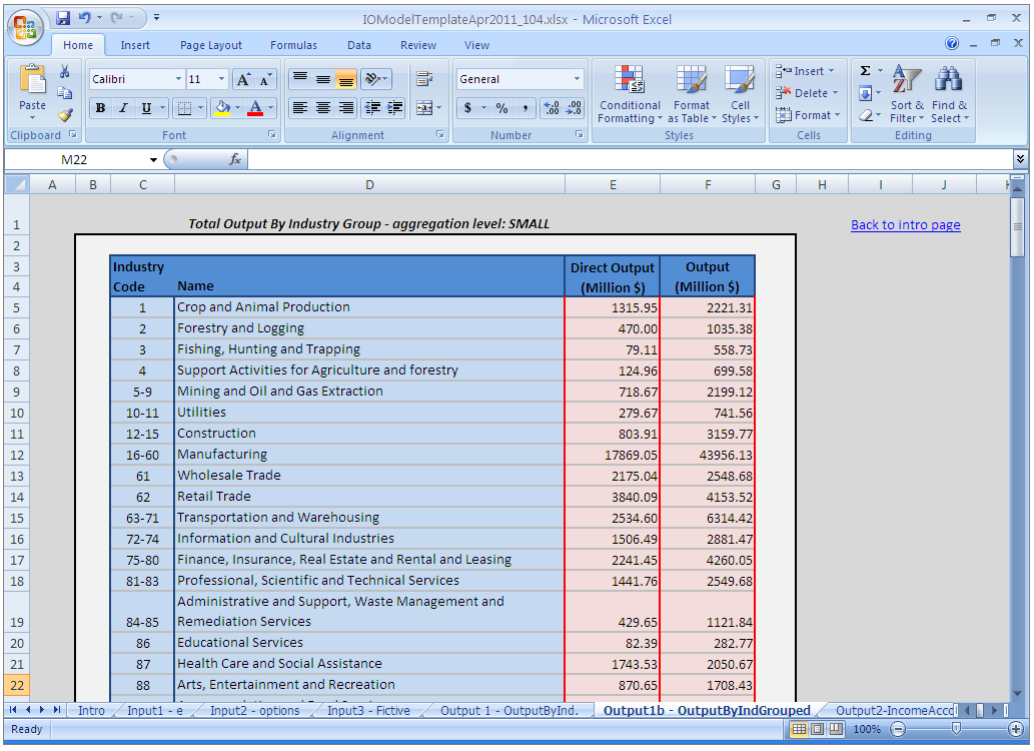


*Total Output By Industry - (Dimpact*Inverse)*

Back to intro page

Industry Code	Name	Direct Output (Million $)	Output (Million $)
1	Crop and Animal Production	1315.95	2221.31
2	Forestry and Logging	470.00	1035.38
3	Fishing, Hunting and Trapping	79.11	558.73
4	Support Activities for Agriculture and Forestry	124.96	699.58
5	Oil and Gas Extraction	240.48	439.59
6	Coal Mining	8.27	274.77
7	Metal Ore Mining	208.05	518.87
8	Non-Metallic Mineral Mining and Quarrying	229.39	533.85
9	Support Activities for Mining and Oil and Gas Extraction	32.49	432.04
10	Electric Power Generation, Transmission and Distribution	157.21	319.42
11	Natural Gas Distribution, Water, Sewage and Other Systems	122.46	422.14
12	Residential Building Construction	93.23	941.84
13	Non-residential Building Construction	597.65	1205.59
14	Repair Construction	100.00	645.19
15	Other Activities of the Construction Industry	13.03	367.14
16	Animal Food Manufacturing	202.35	1172.93
17	Sugar and Confectionery Product Manufactuing	2.86	407.13
18	Fruit and Vegetable Preserving and Specialty Food Manufacturing	443.63	1181.19
19	Dairy Product Manufacturing	549.55	2089.87
20	Meat Product Manufacturing	275.02	1739.88
21	Seafood Product Preparation and Packaging	83.19	519.33

Figure 5: DIO 4.1 Screenshot - Output by industry



Total Output By Industry Group - aggregation level: SMALL

Back to intro page

Industry Code	Name	Direct Output (Million $)	Output (Million $)
1	Crop and Animal Production	1315.95	2221.31
2	Forestry and Logging	470.00	1035.38
3	Fishing, Hunting and Trapping	79.11	558.73
4	Support Activities for Agriculture and forestry	124.96	699.58
5-9	Mining and Oil and Gas Extraction	718.67	2199.12
10-11	Utilities	279.67	741.56
12-15	Construction	803.91	3159.77
16-60	Manufacturing	17869.05	43956.13
61	Wholesale Trade	2175.04	2548.68
62	Retail Trade	3840.09	4153.52
63-71	Transportation and Warehousing	2534.60	6314.42
72-74	Information and Cultural Industries	1506.49	2881.47
75-80	Finance, Insurance, Real Estate and Rental and Leasing	2241.45	4260.05
81-83	Professional, Scientific and Technical Services	1441.76	2549.68
84-85	Administrative and Support, Waste Management and Remediation Services	429.65	1121.84
86	Educational Services	82.39	282.77
87	Health Care and Social Assistance	1743.53	2050.67
88	Arts, Entertainment and Recreation	870.65	1708.43

Figure 6: DIO 4.1 Screenshot - Output by industry groups

The following output page is the *Income Account Summary* (Figure 7) and shows the direct and indirect impact of DND expenditures on the different primary inputs. All entries are in Million $.

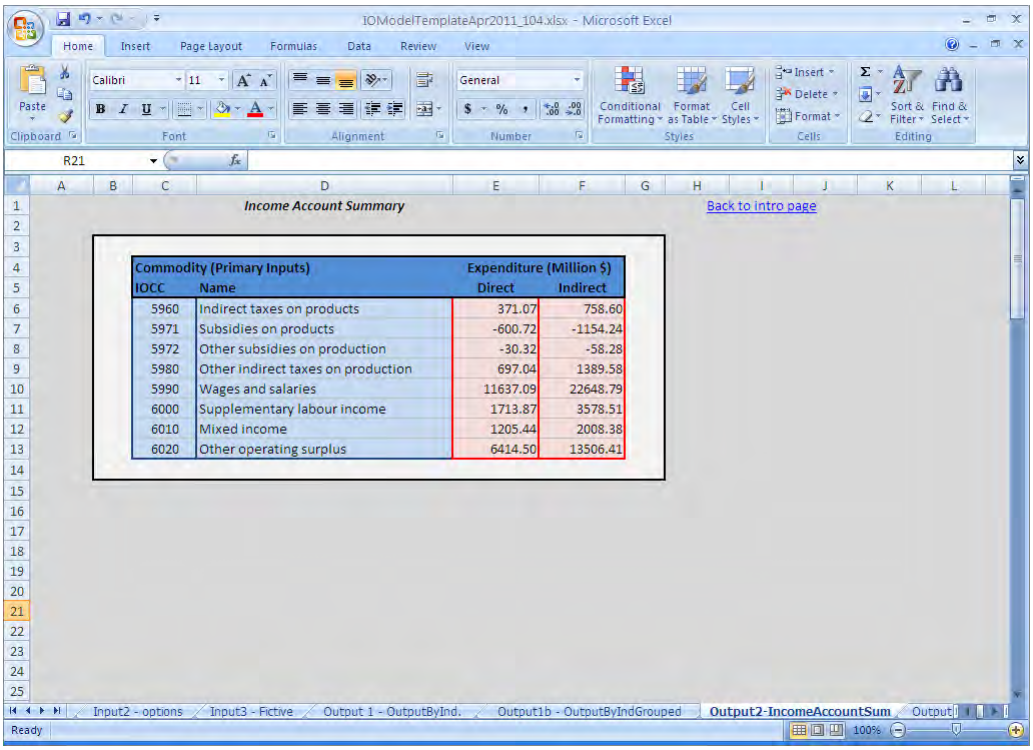
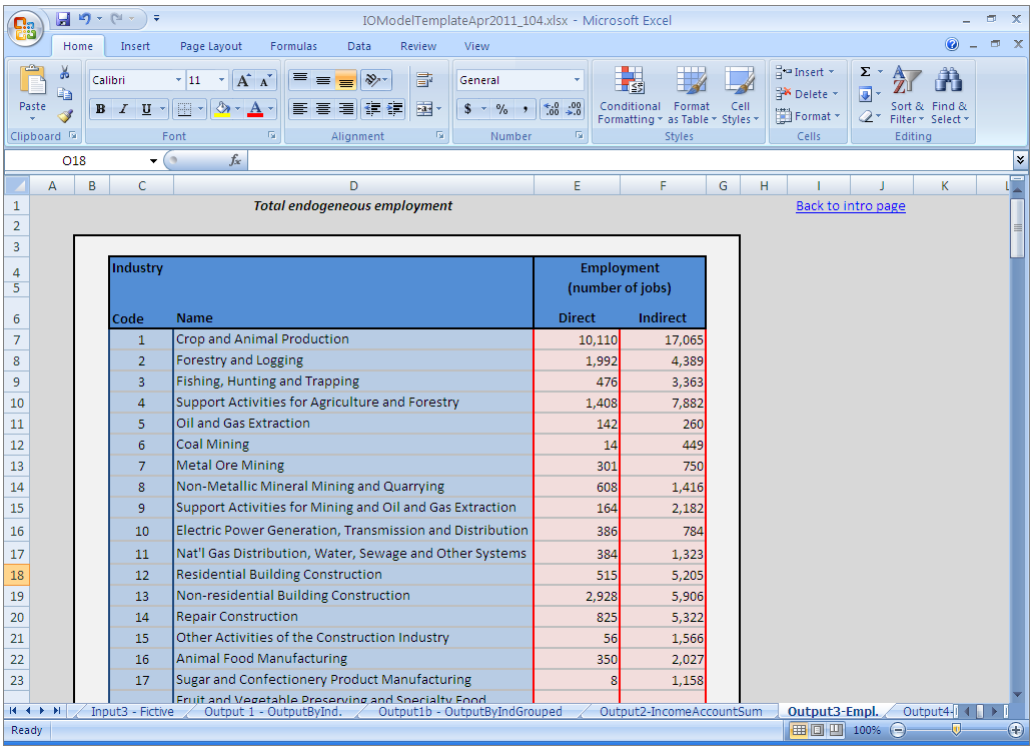


Figure 7: DIO 4.1 Screenshot - Income account summary

Next is the simulation output in terms of employment potential (Figure 8). The tab *Output3 - Empl* shows a table of the estimated number of jobs created as a consequence of the defence expenditures vector entered in the first input sheet. The table shows direct and indirect jobs in the last two columns and for each of the 104 industries considered in the model.

The final demand vector and leakages are shown on the following page (Figure 9), accessed with the tab *Ouput4 - FinalDemand*. This page summarizes information already displayed in previous output pages and emphasizes the total economic leakage. Column totals can be found at the bottom of the table.

Finally the last output page shows the results of Consumer induced expenditures calculations (Figure 10) explained in the previous section and can be accessed with the tab *Output5 - CIM Results*.



Total endogeneous employment

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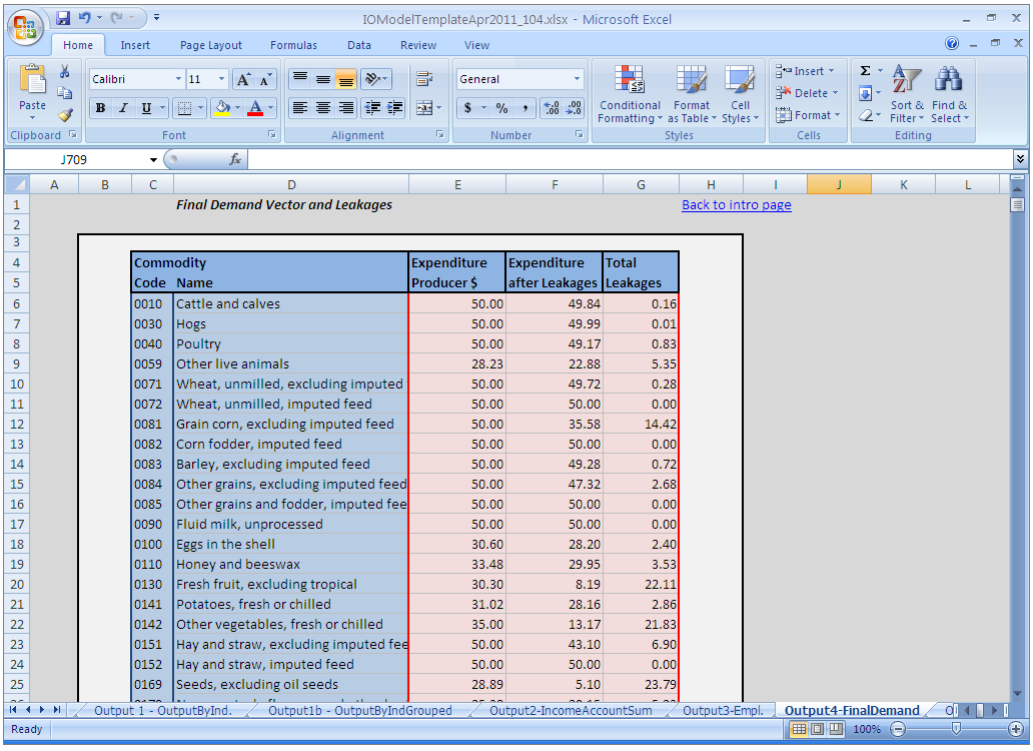
Industry Code	Industry Name	Employment (number of jobs) Direct	Employment (number of jobs) Indirect
1	Crop and Animal Production	10,110	17,065
2	Forestry and Logging	1,992	4,389
3	Fishing, Hunting and Trapping	476	3,363
4	Support Activities for Agriculture and Forestry	1,408	7,882
5	Oil and Gas Extraction	142	260
6	Coal Mining	14	449
7	Metal Ore Mining	301	750
8	Non-Metallic Mineral Mining and Quarrying	608	1,416
9	Support Activities for Mining and Oil and Gas Extraction	164	2,182
10	Electric Power Generation, Transmission and Distribution	386	784
11	Nat'l Gas Distribution, Water, Sewage and Other Systems	384	1,323
12	Residential Building Construction	515	5,205
13	Non-residential Building Construction	2,928	5,906
14	Repair Construction	825	5,322
15	Other Activities of the Construction Industry	56	1,566
16	Animal Food Manufacturing	350	2,027
17	Sugar and Confectionery Product Manufacturing	8	1,158
	Fruit and Vegetable Preserving and Specialty Food		

Figure 8: DIO 4.1 Screenshot - Employment potential



Final Demand Vector and Leakages

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Commodity Code	Commodity Name	Expenditure Producer $	Expenditure after Leakages	Total Leakages
0010	Cattle and calves	50.00	49.84	0.16
0030	Hogs	50.00	49.99	0.01
0040	Poultry	50.00	49.17	0.83
0059	Other live animals	28.23	22.88	5.35
0071	Wheat, unmilled, excluding imputed	50.00	49.72	0.28
0072	Wheat, unmilled, imputed feed	50.00	50.00	0.00
0081	Grain corn, excluding imputed feed	50.00	35.58	14.42
0082	Corn fodder, imputed feed	50.00	50.00	0.00
0083	Barley, excluding imputed feed	50.00	49.28	0.72
0084	Other grains, excluding imputed feed	50.00	47.32	2.68
0085	Other grains and fodder, imputed fee	50.00	50.00	0.00
0090	Fluid milk, unprocessed	50.00	50.00	0.00
0100	Eggs in the shell	30.60	28.20	2.40
0110	Honey and beeswax	33.48	29.95	3.53
0130	Fresh fruit, excluding tropical	30.30	8.19	22.11
0141	Potatoes, fresh or chilled	31.02	28.16	2.86
0142	Other vegetables, fresh or chilled	35.00	13.17	21.83
0151	Hay and straw, excluding imputed fee	50.00	43.10	6.90
0152	Hay and straw, imputed feed	50.00	50.00	0.00
0169	Seeds, excluding oil seeds	28.89	5.10	23.79

Figure 9: DIO 4.1 Screenshot - Final demand and leakages

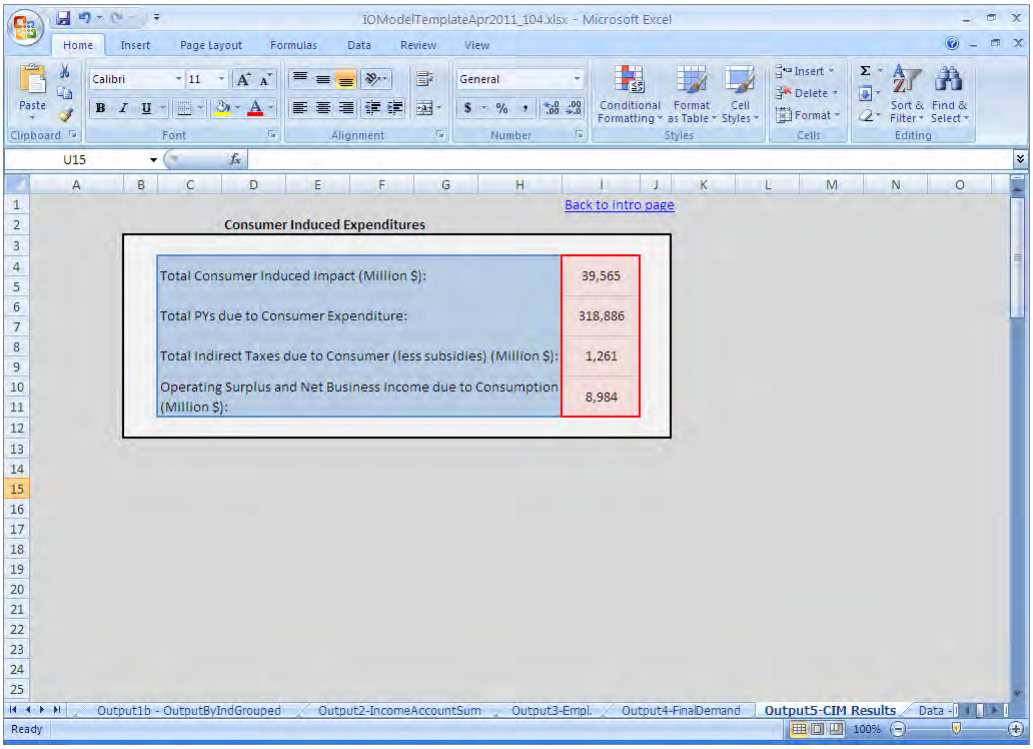

Figure 10: DIO 4.1 Screenshot - Consumer Induced Expenditures

Data and calculations

The tabs with labels starting with *Data* or *Calcs* hold all the underlying data and calculations necessary to run the simulation. The experienced user can use these pages to follow the Input-Output model calculations however modifying the information on these pages (even formats) can affect the outcome of the calculations. It may be advisable to keep a copy of the original spreadsheet in case the information on these pages is inadvertently modified.

5 Conclusion and future developments

Conclusion

The Defence Input-Output model version 4.1 (DIO 4.1) developed by DRDC CORA's Defence Economics team constitutes a significant improvement on past versions of the DND Input-Output model both in the treatment of data and in the presentation.

As with past models, DIO 4.1 is grounded in the economic principle of general equilibrium developed by Leontief (Leontief (1951)) and provides an empirical analysis of the economic impact of DND expenditures on the Canadian economy.

The model is based on industrial production statistics compiled by Statistics Canada (SC) for the year 2006 (the more recent year of publicly available data). The SC data details the input requirements, employment and output of different industrial sectors of the Canadian economy as well as inter-industry relationships and consumption patterns for different agents of the economy ranging from households to governments. As part of the development of DIO 4.1, the data was adapted to highlight the military industrial sector.

As with all I-O models, there are important limitations to DIO 4.1. A first set of limitations is related to the SC data with the publicly available data typically dated by three to five years and also partially censored for reasons of confidentiality. A second set of limitations results from the static nature of the model. While I-O models can quantify economic impact in terms of jobs and output ($) they do not provide any indication of the dynamics of the impact. In other words, the time over which the impact could play out and the second-level effects are not known although spill-over effects into other industries are modeled using some simple assumptions. The Leontief assumptions also imply linearity in the production factors, i.e. the constant proportionality of inputs and outputs. As a result the model does not consider technological progress or possible economies of scale.

Input-Output models are also not explicit about variations in consumer behavior. In the context of a recession for instance household may have more incentive to save or to substitute one product for another to adapt to changing prices.

Despite these limitations, DIO 4.1 provides and interactive and easy to use interface to run simulations and compare the impact of different decisions concerning DND expenditures. Through scenario exploration, DIO 4.1 provides a way to improve the general quality of DND impact assessment for DND staff outside of CORA. DIO 4.1 is also a reusable tool for the OR community for future economic impact studies.

Future developments

With the new Excel version, the DIO model can now be updated relatively easily as new economic data is released by SC. With minor data manipulations, the Defence Economics team will be able to maintain the DIO as current as possible.

While it would be interesting to break down the model into similar provincial or regional Input-Output models, for instance to study the regional benefits of different large procurement programmes, the data censorship limitation would significantly lower the fidelity of sub-national level models. It is however possible to look at the combination of the national-level I-O model with other models to further understand economic impact on specific geographic regions. The mapping of provincial economic multipliers to the DIO output could be investigated.

Finally the combination of dynamic models and static input-output models constitute an avenue for future research for the new Defence Economics team.

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Annex A
Commodities in DIO 4.1

Table A.1: Commodities in DIO 4.1

Index	Code	Commodity name
1	0010	Cattle and calves
2	0030	Hogs
3	0040	Poultry
4	0059	Other live animals
5	0071	Wheat, unmilled, excluding imputed feed
6	0072	Wheat, unmilled, imputed feed
7	0081	Grain corn, excluding imputed feed
8	0082	Corn fodder, imputed feed
9	0083	Barley, excluding imputed feed
10	0084	Other grains, excluding imputed feed
11	0085	Other grains and fodder, imputed feed
12	0090	Fluid milk, unprocessed
13	0100	Eggs in the shell
14	0110	Honey and beeswax
15	0130	Fresh fruit, excluding tropical
16	0141	Potatoes, fresh or chilled
17	0142	Other vegetables, fresh or chilled
18	0151	Hay and straw, excluding imputed feed
19	0152	Hay and straw, imputed feed
20	0169	Seeds, excluding oil seeds
21	0170	Nursery stock, flowers, and other horticulture products
22	0181	Canola
23	0182	Soybeans and other oil seeds
24	0200	Raw tobacco
25	0219	Raw wool and mink skins
26	02311	Services incidental to crop production
27	02312	Services incidental to animal production
28	02313	Veterinary fees
29	02314	Tree pruning and surgery services
30	02315	Animal (pet) training, grooming and boarding services
31	0232	Services incidental to forestry
32	0249	Logs
33	0259	Other wood in the rough including poles, piling and bolts
34	0260	Pulpwood
35	0270	Other forestry products including fuel wood and cork
36	0280	Custom forestry

Index	Code	Commodity name
37	02901	Fish and seafood (except animal aquaculture), fresh, chilled or frozen
38	02902	Animal aquaculture products, fresh, chilled or frozen
39	0300	Hunting and trapping products
40	0320	Gold and alloys in primary forms
41	0340	Iron ores and concentrates
42	03501	Bauxite ore
43	03502	Alumina (refined bauxite)
44	03601	Copper, nickel, lead and zinc ores and concentrates
45	03602X	Radioactive and all other miscellaneous metal ores and concentrates
46	0370	Coal
47	0380	Crude mineral oils
48	0390	Natural gas, excluding liquefied
49	0410	Sulphur
50	0430	Gypsum
51	0440	Salt
52	0450	Peat
53	0460	Clays
54	0470	Natural abrasives and industrial diamonds
55	04801	Unsorted and non-industrial diamonds
56	04802X	Asbestos and other miscellaneous non-metallic minerals
57	0490	Sand and gravel, excluding silica
58	0501	Stone and silica sand for industrial use
59	0502	Building and crushed stone
60	0510	Services incidental to mining
61	0521	Beef, fresh, chilled or frozen
62	0522	Pork, fresh, chilled or frozen
63	0523	Other meat excluding poultry, fresh, chilled or frozen
64	0524	Edible offal excluding poultry, fresh, chilled or frozen
65	0540	Cured meat
66	0559	Prepared meat products
67	0570	Animal fat and lard
68	0580	Margarine and shortening
69	0590	Sausage casings
70	0619	Feeds from animal by-products
71	0620	Raw animal hides and skins
72	0639	Animal by-products for industrial use
73	0640	Custom work, meat and food
74	0650	Poultry, fresh, chilled or frozen

Index	Code	Commodity name
75	0679	Fluid milk, processed
76	0680	Fresh cream
77	0690	Butter
78	0700	Cheese
79	0719	Evaporated and condensed dairy products
80	0720	Ice cream
81	0731	Powdered dairy products
82	0732	Other miscellaneous dairy products
83	0740	Mayonnaise, salad dressing and mustard
84	0751	Fish and seafood products, fresh, chilled or frozen
85	0752	Fish and seafood products, canned or otherwise preserved
86	0761	Frozen fruit and juice concentrates
87	0762	Fruit juices, excluding frozen concentrates
88	0763	Other fruit products including dried fruit and fruit peel
89	0770	Fruit and jam in airtight containers
90	0781	Frozen potatoes
91	0782	Other frozen vegetables
92	0783	Other preserved vegetables
93	0790	Vegetables and vegetable juices in airtight containers
94	0800	Soups in airtight containers
95	0810	Infant and junior foods in airtight containers
96	0820	Pickles, relishes and other sauces
97	0830	Vinegar
98	0841	Mineral water, fruit-flavoured beverages and ice
99	0842	Pasta products, excluding dry pasta
100	0843	Prepared meals
101	0850	Feed supplements and premixes
102	0860	Complete feeds
103	0879	Feeds from grain by-products
104	0889	Feeds from vegetable by-products
105	0890	Pet feeds
106	0900	Wheat flour
107	0919	Starches
108	0920	Breakfast cereal products
109	0930	Biscuits
110	0940	Bread and rolls
111	0951	Other bakery products
112	0952	Food snacks excluding potato chips and nuts
113	0960	Cocoa and chocolate
114	0979	Nuts

Index	Code	Commodity name
115	0989	Chocolate confectionery
116	0999	Other confectionery
117	1010	Sugar
118	1030	Feeds from vegetable oil by-products including oil cake and other residues
119	1040	Crude vegetable oils
120	1059	Nitrogen function compounds
121	1069	Other flours and processed grains
122	1071	Maple sugar and syrup
123	1072	Molasses and other syrups
124	1080	Prepared cake and other mixes
125	1090	Dehydrated soup mixes and bases
126	1100	Roasted coffee
127	1110	Tea
128	1120	Potato chips and flakes
129	1131	Spices
130	1132	Peanut butter
131	1133	Food and drink powders
132	1134	All other miscellaneous food products
133	1135	Infant and junior foods, excluding in airtight containers
134	1136	Dry pasta
135	1140	Soft drink concentrates
136	1150	Carbonated soft drinks
137	1161	Distilled alcohol beverages, bought in stores
138	1162	Distilled alcohol beverages, consumed on license premises
139	1191	Beer including coolers, bought in stores
140	1192	Beer including coolers, consumed on license premises
141	1201	Wine including coolers, bought in stores
142	1202	Wine including coolers, consumed on license premises
143	1219	Unmanufactured tobacco
144	1220	Cigarettes
145	1239	Other tobacco products
146	1240	Waterproof footwear
147	1250	Motor car tires
148	1279X	Tires and tubes excluding motor car tires
149	1289	Tire repair material and rethreaded tires
150	1300	Conveyor and transmission belting
151	1311	Self-adhesive tape (in rolls of a width not exceeding 20 cm)
152	1312	Other rubber products
153	1320	Hose and tubing, mainly rubber

Index	Code	Commodity name
154	13511	Plastic film and sheet, not laminated
155	13512	Laminated plastic plates, sheets and shapes
156	1352	Foamed and expanded plastics
157	1353	Other plastic products, including cups
158	1354	Plastic building supplies
159	1355	Other rubber end-products
160	1360	Plastic containers and closures
161	1389	Plastic pipe and pipe fittings
162	1399	Leather, chamois, composition leather and parings and other waste of leather
163	1400	Footwear, excluding waterproof
164	1410	Leather gloves
165	1430	Trunks, suitcases, briefcases, school satchels and similar containers
166	1440	Handbags, wallets and similar personal articles such as eyeglass and cigar cases and coin purses
167	1450	Cotton yarn
168	1470	Cotton woven fabric
169	1480	Tire cord fabric
170	1509	Bedding
171	1519	Wool and wool mix yarn and thread
172	1520	Wool and wool mix woven fabric
173	1539	Felt
174	1540	Man-made staple fibres
175	1550	Polyamide resins, including nylon
176	1561	Filament yarn
177	1562	Yarn of staple fibres
178	1570	Tire yarn
179	1581	Man-made fabric for clothing
180	1582	Man-made fabric for industrial use
181	1583	Pile fabric
182	1620	Cotton thread
183	1630	Man-made thread
184	1659	Rope and twine
185	1679	Narrow fabrics, including lace
186	1700	Textile floor covering
187	1710	Textile dyeing and finishing service
188	1729	Tarpaulins, awnings and sunblinds
189	1730	Tents, sails and sleeping bags
190	1789	Other household textile products
191	1791	Textile medical products
192	1792	Other textile products

Index	Code	Commodity name
193	1800	Hosiery
194	1829	Knitted fabrics
195	1831	Men's and boys' knitted clothing
196	1832	Sweaters
197	1833	Women's knitted clothing
198	1834	Children's knitted clothing
199	1841	Men's and boys' clothing, excluding knitted
200	1842	Women's underwear and sleepwear
201	1843	Other women's clothing, excluding knitted
202	1844	Children's wear, excluding knitted
203	1859	Other clothing and accessories, excluding dressed furs and fur apparel
204	1869	Dressed furs
205	1880	Fur apparel
206	1890	Custom tailoring
207	1900	Wood chips
208	1911	Lumber and timber, not treated
209	1912	Lumber and timber, treated
210	1930	Wood waste including saw dusts, shavings and peeler log cores
211	1940	Custom wood work and millwork
212	1950	Plywood and veneer
213	1961	Wooden doors and windows
214	1962	Kitchen cabinets
215	1963	Other millwork
216	1979	Wood structural products
217	1980	Wood prefabricated buildings
218	1999	Wood containers and pallets
219	2000	Caskets and coffins
220	2011	Shingles and shakes
221	2012	Particle and wafer board
222	2013	Other wood end-products
223	2041	Household furniture
224	2042	Furniture parts
225	2050	Office furniture
226	2069	Commercial and institutional furniture
227	2079	Mattresses and other furniture
228	2089	Table, desk, bedside and floor lamps
229	2090	Wood pulp
230	2100	Newsprint paper
231	2119	Other paper, containing wood

Index	Code	Commodity name
232	2129	Other paper, wood free
233	2139	Tissue and sanitary paper stock
234	2149	Wrapping and sack paper and paper bag stock
235	2159	Paperboard, including boxboard
236	2161	Building board and paper
237	2162	Asphalt building products
238	2179	Toilet paper, facial tissues, paper towel, paper serviettes and paper napkins and tablecloths
239	2199	Paper waste and scrap
240	2200	Vinyl floor and wall covering
241	2211	Paper bags and sacks
242	2212	Paper boxes, cartons and drums
243	2213	Plastic bags
244	2221	Corrugated paper and board
245	2222	Wallpaper
246	2223	Other coated paper and coated paper products
247	2239	Aluminium foil
248	2241	Paper diapers and sanitary napkins
249	2242	Textile hygiene products
250	2259	Paper containers for commercial use
251	2261	Paper stationery
252	2262	Other stationery supplies
253	2263	Photographic paper
254	2270	Other paper end-products
255	2281	Newspapers
256	2282	Magazines and periodicals
257	2291	Books
258	2292	Greeting cards, post cards, maps and charts
259	2300	Unused postage stamps, banknotes, cheque forms, and stock and bonds certificates and similar documents of title
260	2311	Printed business forms
261	2312	Advertising flyers, catalogues, and directories
262	2313	Other printed products
263	2320	Advertising in print media
264	2330	Specialized publishing service
265	23401	Printing type, blocks, plates, cylinders and other printing components
266	23402	Support activities for printing
267	2369X	Ferro-alloys and iron and steel ingots, billets and other primary forms
268	2380	Steel castings
269	2391	Steel bars and rods, non-alloy, excluding reinforced
270	2392	Reinforcing bars and rods

Index	Code	Commodity name
271	2393	Alloy steel bars and rods
272	2419	Flat iron and steel, not alloy, not coated
273	2429	Flat iron and steel, alloy, coated
274	2440	Iron and steel railway construction material
275	2450	Tar and pitch
276	2460	Carbon and graphite products
277	2480	Oil and gas casing and drill pipe
278	2490	Oil and gas line pipe
279	2509	Other iron and steel pipes and tubes
280	2511	Other cast iron products
281	2512	Grinding balls and ingot moulds
282	2521	Cast iron pipe and fittings
283	2522	Other iron and steel pipe fittings
284	2530	Nickel in primary forms
285	2540	Copper in primary forms
286	2571	Aluminium and alloy ingots, billets, blocks and slabs
287	2572	Aluminium and alloys in other primary forms
288	2590	Precious metals in primary forms excluding gold
289	2600X	Lead, zinc and other non-ferrous metals in primary forms
290	2609	Other primary products of other non-ferrous metals
291	2629	Other inorganic bases and metallic oxides
292	2631	Metal scrap and waste, excluding iron and steel
293	2632	Iron and steel scrap and waste
294	2649	Other primary products of aluminium and aluminium alloys, excluding castings
295	2650	Other primary products of non-alloy copper, excluding castings
296	2660	Other primary products of copper alloys, excluding castings
297	2670	Other primary products of lead and lead alloys, excluding castings
298	2680	Other primary products of nickel and nickel alloys, excluding castings
299	2690	Non-ferrous metal castings
300	2710	Soldering rods and wire
301	2720	Fabricated steel plate
302	2730	Metal tanks
303	2749	Power boilers
304	2760	Iron and steel structural materials
305	2781	Prefabricated metal buildings
306	2782	Prefabricated metal structures
307	2791	Metal doors and windows
308	2792	Other metal building products
309	2810	Corrugated metal culvert pipe

Index	Code	Commodity name
310	2820	Iron and steel stampings
311	2839	Metal roofing, siding, ceilings, partitions, decks and balconies
312	2851	Metal kitchen utensils
313	2852	Other kitchen utensils
314	2861	Other metal containers and closures
315	2862	Food, beverage and other cans
316	2870	Iron and steel wire and cable
317	2880	Iron and steel wire fencing and screen
318	2890	Chain, excluding motor vehicle and power transmission
319	2900	Welding rods and wire electrodes
320	2919	Wire products, including springs
321	2929	Fastener hardware
322	2939	Builders' hardware
323	2949	Other hardware
324	2961	Machine tools
325	2962	Tool accessories
326	2979	Hand and measuring tools
327	2980	Scissors, razor blades and manicure and pedicure sets
328	2991	Household clothes washers and dryers
329	2992	Household dishwashers
330	2993	Lawn mowers, snow blowers, and lawn sprinklers
331	3019	Non-electric furnaces and heating equipment
332	3049	Commercial cooking equipment
333	30501	Custom metal working, excluding coating, engraving, and heated treated metal
334	30502	Coated, engraved, heat treated or similarly treated metal products
335	3060	Iron and steel forgings
336	3070	Valves
337	3081	Metal plumbing fixtures and fittings
338	3082	Plastic plumbing fixtures and fittings
339	3090	Gas and water meters
340	3100	Fire fighting and traffic control equipment
341	3120	Firearms and military hardware
342	31491X	Wheel and crawler tractors and engines, parts and assemblies thereof
343	3150	Other agricultural machinery
344	3161	Bearings
345	3162	Mechanical power transmission equipment
346	3170	Pumps, compressors, fans and blowers
347	3180	Conveyors, elevators and hoisting machinery
348	3190	Industrial trucks and material handling equipment

Index	Code	Commodity name
349	3200	Fans and air circulation units, not industrial
350	3211	Packaging and bottling machinery
351	3212	Air purification equipment
352	3213	Other general purpose machinery
353	3220	Industrial furnaces, kilns and ovens
354	32311	Construction machinery
355	32312	Mining and oil and gas field machinery
356	3232	Logging and pulp and paper industry machinery
357	3233	Metal working machinery
358	3234	Other industry specific machinery
359	3235	Service industry machinery
360	3240	Power hand tools
361	3261	Air conditioning equipment, wall and window
362	3262	Air conditioning and refrigeration equipment, commercial and transport
363	3270	Scales and balances
364	3280	Vending machines
365	3291	Computers and peripherals equipment such as terminals, printers and storage devices
366	3292	Office equipment, excluding photocopy and fax machines
367	3310X	Aircraft and aircraft engines
368	3320	Aircraft parts and equipment
369	3330	Aircraft service and repairs
370	33401	Automobiles, excluding passenger vans
371	33402	Passenger vans
372	33403	Used motor vehicles (business to persons)
373	3350	Trucks, road tractors and chassis
374	3360	Buses and chassis
375	3371	Off-highway trucks
376	3372	Military motor vehicles
377	3373	Motor homes, motorcycles and atvs
378	3380	Mobile homes
379	3391	Non-commercial trailers
380	3392	Commercial trailers and semi-trailers
381	3409	Truck and bus bodies and cargo containers
382	3410	Motor vehicle engines and parts
383	3420	Motor vehicle electric equipment
384	3431	Motor vehicle stampings
385	3432	Motor vehicle steering and suspension
386	34331	Motor vehicle wheels
387	34332	Motor vehicle brakes

Index	Code	Commodity name
388	3434	Motor vehicle plastic parts and trim
389	3435	Motor vehicle fabric accessories
390	34361X	Motor vehicle transmission and power train parts and other motor vehicle parts and accessories
391	3459	Locomotive, railway and urban transport rolling stock
392	3470	Parts for locomotive, railway and urban transport rolling stock
393	3489	Ships and boats and parts thereof, excluding pleasure boats and sporting craft
394	3500	Ship repairs
395	3519	Snowmobiles
396	3520	Pleasure boats and sporting craft
397	3531	Microwave ovens
398	35321	Sewing machines, vacuum cleaners and floor polishers
399	35322	Other small household appliances
400	3549	Electric furnace and other electric heating equipment
401	3550	Household refrigerators and freezers
402	3560	Household cooking equipment, excluding microwave ovens
403	3571	Radio, stereo, cassette and CD players and similar equipment, and accessories
404	35721	TV, VCR, and accessories
405	35722	Unrecorded tapes (blanks)
406	3580	Telephone and related equipment, including fax machines
407	3599	Broadcasting and radio communications equipment
408	3600	Radar and radio navigation equipment
409	3619	Semi-conductors
410	3621	Printed circuits
411	3622	Integrated circuits
412	3623	Other electronic equipment components
413	3630	Electronic alarm and signal systems
414	3650	Welding machinery and equipment
415	3661	Power generation and marine propellers, non-electric
416	3662	Electrical generators and motors
417	3671	Ballast
418	3672	Transformers and converters
419	3689	Industrial electric equipment, including safety
420	3690	Batteries
421	3700	Insulated wire and cable, excluding aluminium
422	3710	Aluminium wire and cable
423	3729	Wiring materials and electrical meters
424	3739	Electric light bulbs and tubes
425	3741	Electric lighting fixtures, excluding portable
426	3742	Vehicle lighting equipment

Index	Code	Commodity name
427	3750	Cement
428	3760	Lime
429	3779	Concrete products
430	3790	Ready-mix concrete
431	3800	Bricks and other clay building products
432	3810	Porcelain insulators
433	3820	Ceramic household products
434	3830	Refractory products
435	3849	Natural stone products
436	3860	Gypsum building products
437	3870	Mineral wool building products
438	3880	Asbestos products
439	3890	Other non-metallic mineral basic products
440	3901	Glass and other glass products
441	3902	Safety glass
442	3903	Optical fibre cables
443	3904	Glass fibres including glass wool and articles thereof, excluding glass woven fabrics and tire cord fabrics
444	3910X	Glass containers, mirrors and other glass household products
445	3930	Abrasive products
446	3950	Motor gasoline
447	3961	Aviation fuel
448	3962	Diesel oil
449	3963	Light fuel oil
450	3964	Heavy fuel oil
451	3970	Lubricating oils and greases
452	3980	Benzene, toluene and xylene
453	3990	Liquid petroleum gases
454	4000	Naphtha
455	4011	Asphalt compound, hot bulk
456	4012	Other asphalt products
457	4020	Petrochemical feed stock
458	4031	Animal and vegetable fertilizers, imputed
459	4032	Animal and vegetable fertilizers, excluding imputed
460	4033	Potash
461	4034	Chemical fertilizers
462	4041	Ethylene polymers
463	4042	Vinyl polymers
464	4043	Other polymers
465	4050	Cellulosic plastic film and sheet

Index	Code	Commodity name
466	4070	Monoethylene glycol
467	4080	Pharmaceuticals
468	4090	Paints and related products
469	4109	Refined vegetable oils
470	4120	Oral care products
471	4131	Soaps
472	4132	Detergents
473	4133	Other cleaning products
474	4149	Other industrial chemical preparations
475	4151	Cosmetic products
476	4152	Hair care products
477	4153	Other personal care products
478	4154	Bleach and fabric softeners
479	4160	Chlorine
480	4170	Oxygen
481	4180	Phosphorous
482	4190	Other chemical elements
483	4200	Sulphuric acid
484	4229	Other inorganic acids and oxygen compounds
485	4230	Ammonia
486	4240	Caustic soda
487	4260	Sodium chlorate
488	4280	Sodium phosphates
489	4290	Sodium carbonate
490	4329	Other metallic salts and peroxysalts
491	4331	Deuterium oxide (heavy water)
492	4332	Radioactive chemicals
493	4333	Other inorganic chemicals
494	4340	Ethylene
495	4350	Butylenes
496	4360	Butadiene
497	4380	Styrene
498	4400	Vinyl chloride
499	4449	Other hydrocarbons and derivatives
500	4450	Methyl alcohol
501	4499	Other alcohols and derivatives
502	4520	Ethers and epoxy derivatives of alcohols
503	4539	Other phenols, aldehydes and ketones
504	4599	Organic acids and derivatives

Index	Code	Commodity name
505	4630	Organo-inorganic compounds
506	4640	Other organic chemicals
507	4650	Titanium dioxide, excluding slag
508	4660	Carbon
509	4679	Pigments, lakes and dyes
510	4700	Synthetic rubber
511	4710	Antifreeze preparations
512	4729	Additives and automobile chemicals
513	4740	Rubber and plastic compounding agents
514	4759	Explosives and non-military ammunition
515	4770	Military ammunition and ordnance
516	4790	Crude vegetable materials and extracts
517	4810	Insecticides and herbicides
518	4820	Adhesives
519	4860	Catalysts
520	4870	Metal working industrial chemicals
521	4880	Printing and other inks
522	4900	Polish, cream and wax products
523	4949	Other oils, fats and waxes
524	4970	Aircraft and nautical navigation instruments, excluding radio
525	4999X	Laboratory and scientific instruments, flight simulators, and measuring and controlling instruments
526	5001	Medical and dental equipment and supplies
527	5002	Ophthalmic goods
528	5003	Personal medical goods
529	5010	Industrial safety equipment
530	5020	Clocks and watches and parts thereof, excluding watch straps, bands and bracelets
531	5031	Optical and photographic equipment
532	5032	Photocopy and microfilm equipment
533	5033	Photographic film and plate
534	5049	Pearls and precious stones excluding diamonds, jewellery and imitation jewellery, and articles of precious metals including silverware
535	5060	Brooms, mops and brushes of all kinds
536	5079	Bicycles
537	5080	Recreational equipment
538	5099	Toys and games, including electronic
539	5100	Impregnated and coated fabrics
540	5110	Floor and wall covering, backed with paper
541	5120	Illuminated signs, illuminated name-plates and the like
542	5130	Shades and blinds
543	5151	Custom work, refined petroleum and coal

Index	Code	Commodity name
544	5159	Other custom work
545	5179	Hair and bristles of pigs, hogs, boars, baggers and horses, coarse animal hair not carded or combed, and waste of these products
546	5189	Other metal end-products
547	5190	Sewing needs
548	52011	Recorded media, including music, movies and pre-packaged software
549	52012	Musical instruments and artists' supplies
550	5202	Smokers' supplies
551	5219	Art and decorative goods and miscellaneous end products
552	5220	Repair construction
553	5230	Residential building construction
554	5240	Non-residential building construction
555	5250	Road, highway and airport runway construction
556	5260	Gas and oil facility construction
557	5270	Electric power, dams and irrigation construction
558	5280	Railway and telecommunications construction
559	5290	Other engineering construction
560	5301	Air transportation, passenger
561	5302	Air transportation, freight
562	5303	Air transportation, specialty
563	5304	Services incidental to air transportation
564	53111	Scenic and sightseeing transportation, bus
565	53112	School bus and other transportation
566	5312	Ambulance services
567	5321	Travel agents, tour wholesaler and operator services
568	5322	Parking services
569	5323	Other services incidental to transportation
570	5331	Water transportation, passenger
571	5332	Water transportation, freight
572	5333	Water transportation, other
573	5340	Services incidental to water transportation
574	5351	Rail transportation, passenger
575	5352	Rail transportation, freight
576	5353	Services incidental to rail transport
577	5360	Truck transportation
578	5371	Bus transportation, interurban and rural, passenger
579	5372	Bus transportation, interurban and rural, parcel express
580	5380	Urban transit
581	5390	Taxi and limousine transportation services
582	54001	Pipeline transportation of natural gas

Index	Code	Commodity name
583	54002	Crude oil and other pipeline transportation
584	5410	Highway and bridge maintenance
585	5421	Grain storage
586	5422	Other storage and warehousing
587	54301	Radio and television broadcasting, except cable
588	54302	Cable and other subscription programming
589	5440	Telephone and other telecommunication services
590	5450X	Postal and courier services
591	5460	Electric power
592	5470	Gas distribution
593	5480	Coke
594	5491	Water supply
595	5492	Other utilities
596	5500	Wholesaling margins
597	55101	Automotive repair and maintenance service
598	55102	Other repair and maintenance
599	5520	Rental of office equipment
600	5531	Retailing margins
601	5532	Retailing service
602	5541	Central bank
603	55421	Implicit charges, deposits, banking and other deposit credit intermediation
604	55422	Implicit charges, loans, banking and other deposit credit intermediation
605	5551	Paid charges, banks and other deposit account intermediation
606	55521	Implicit charges, deposits, local credit unions
607	55522	Implicit charges, loans, local credit unions
608	5553	Paid charges, credit unions and caisses pop
609	5555	Commissions, investment banking and securities dealing
610	5556	Implicit charge, non-depository credit intermediation
611	5557	Mutual funds
612	55581	Other securities, funds, and related services
613	55582X	Other non-depository credit intermediation services and royalties and licence fees (excluding natural resource)
614	55583	Management fees of companies and enterprises
615	5559	Real estate commissions and management fees
616	5561	Life insurance
617	5562	Non-life insurance
618	5563	Trusteed pension funds
619	5564	Insurance commissions
620	5570	Gross imputed rent
621	5580	Gross paid residential rent

Index	Code	Commodity name
622	5591	Imputed lodging
623	5592	Lodging in universities
624	5593	Other paid lodging, excluding universities
625	5594	Non-residential rent
626	56101	University fees
627	56102	Elementary and secondary school fees
628	56103	College and C.E.G.E.P. fees
629	56104	Other education fees
630	5620	Private hospital services
631	5631	Private residential care facilities
632	5632	Child care, outside the home
633	5633	Other health and social services
634	56341	Laboratory services
635	56342	Physician services
636	56343	Dental service
637	56344	Other health practitioner services
638	5641	Motion picture, audio, and video product and distribution
639	5642	Motion picture exhibition
640	5651	Lottery and other gambling
641	5652	Race track services
642	5653	Other amusement and recreation services
643	5661	Architect, engineering, and scientific services
644	5662	Accounting and legal services
645	5670	Advertising services
646	5680	Laundry and dry cleaning services
647	56901	Hotel and motel accommodation services
648	56902	Other accommodation services
649	57001	Meals (outside home)
650	57002	Board paid
651	5721	Barber and beauty services
652	5722	Funeral services
653	5723	Child care, in the home
654	5724	Private household service
655	5725	Other personal care services
656	5730	Photographic services
657	5740	Services to buildings and dwellings
658	57511	Software products development
659	57512	Own-account Software
660	5752	Computer lease and rental (hardware)

Index	Code	Commodity name
661	57531	Data processing services
662	57532	Computer systems design and related services
663	57533	On-line information services
664	57611	Other information services
665	57612	Investigation and security services
666	57613	Other professional, scientific and technical services
667	57614	Other administrative and support services
668	57615	Other personal services
669	5770	Rental of automobiles and trucks
670	57801	Trade unions dues
671	57802	Political parties
672	57803	Other membership organization dues
673	5791	Rental, video and recreation equipment
674	5792	Rental, other machinery and equipment including construction
675	5800	Spare parts and maintenance supplies
676	5810	Office supplies
677	5820	Cafeteria supplies
678	5830	Transportation margins
679	5840	Laboratory equipment and supplies
680	5850	Travelling and entertainment
681	5860	Advertising and promotion
682	58701	Religious organization services
683	58702	Social assistance services provided by non-profit institutions serving households
684	58703	Art, entertainment and recreation services provided by non-profit institutions serving households
685	58704	Education services provided by non-profit institutions serving households
686	587051	Other services provided by non-profit institutions serving households
687	587052	Aboriginal government services
688	58706	Government funding of hospital
689	58707	Government funding of residential care facilities
690	58708	Government funding of universities
691	587091	Government funding of elementary and secondary schools
692	587092	Government funding of community colleges and C.E.G.E.P's
693	587093	Government funding of other education
694	58710	Defence services
695	58711	Other municipal government services
696	58712	Other provincial government services
697	58713	Other federal government services
698	5880	Raw cotton
699	5890	Natural rubber and gums

Index	Code	Commodity name
700	5900	Raw sugar
701	5910	Cocoa beans
702	5920	Coffee, not roasted
703	5930	Tropical fruit
704	5940	Unallocated imports and exports
705	5950	Sales of other government services
706	5960	Indirect taxes on products
707	5971	Subsidies on products
708	5972	Other subsidies on production
709	5980	Other indirect taxes on production
710	5990	Wages and salaries
711	6000	Supplementary labour income
712	6010	Mixed income
713	6020	Other operating surplus

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Annex B
Industries in DIO 4.1

Table B.1: Industries in DIO 4.1

Index	Code	Industry name
1	11A0	Crop and Animal Production
2	1130	Forestry and Logging
3	1140	Fishing, Hunting and Trapping
4	1150	Support Activities for Agriculture and Forestry
5	2111	Oil and Gas Extraction
6	2121	Coal Mining
7	2122	Metal Ore Mining
8	2123	Non-Metallic Mineral Mining and Quarrying
9	2131	Support Activities for Mining and Oil and Gas Extraction
10	2211	Electric Power Generation, Transmission and Distribution
11	221A	Natural Gas Distribution, Water, Sewage and Other Systems
12	230A	Residential Building Construction
13	230X	Non-residential Building and Engineering Construction
14	230H	Repair Construction
15	230I	Other Activities of the Construction Industry
16	3111	Animal Food Manufacturing
17	3113	Sugar and Confectionery Product Manufacturing
18	3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing
19	3115	Dairy Product Manufacturing
20	3116	Meat Product Manufacturing
21	3117	Seafood Product Preparation and Packaging
22	311A	Miscellaneous Food Manufacturing
23	312A	Soft Drink and Ice Manufacturing
24	312B	Breweries
25	312C	Wineries
26	312D	Distilleries
27	3122	Tobacco Manufacturing
28	31A0	Textile and Textile Product Mills
29	3150	Clothing Manufacturing
30	3160	Leather and Allied Product Manufacturing

Index	Code	Industry name
31	3210	Wood Product Manufacturing
32	3221	Pulp, Paper and Paperboard Mills
33	3222	Converted Paper Product Manufacturing
34	3231	Printing and Related Support Activities
35	3241	Petroleum and Coal Products Manufacturing
36	3251	Basic Chemical Manufacturing
37	3252	Resin, Synthetic Rubber, and Artificial and Synthetic Fibres and Filaments Manufacturing
38	3253	Pesticides, Fertilizer and Other Agricultural Chemical Manufacturing
39	3254	Pharmaceutical and Medicine Manufacturing
40	325A	Miscellaneous Chemical Product Manufacturing
41	3261	Plastic Product Manufacturing
42	3262	Rubber Product Manufacturing
43	3273	Cement and Concrete Product Manufacturing
44	327A	Miscellaneous Non-Metallic Mineral Product Manufacturing
45	3310	Primary Metal Manufacturing
46	3320	Fabricated Metal Product Manufacturing
47	3330	Machinery Manufacturing
48	3341	Computer and Peripheral Equipment Manufacturing
49	334A	Electronic Product Manufacturing
50	3352	Household Appliance Manufacturing
51	335A	Electrical Equipment and Component Manufacturing
52	3361	Motor Vehicle Manufacturing
53	3362	Motor Vehicle Body and Trailer Manufacturing
54	3363	Motor Vehicle Parts Manufacturing
55	3364	Aerospace Product and Parts Manufacturing
56	3365	Railroad Rolling Stock Manufacturing
57	3366	Ship and Boat Building
58	3369	Other Transportation Equipment Manufacturing
59	3370	Furniture and Related Product Manufacturing
60	3390	Miscellaneous Manufacturing
61	4100	Wholesale Trade
62	4A00	Retail Trade
63	4810	Air Transportation

Index	Code	Industry name
64	4820	Rail Transportation
65	4830	Water Transportation
66	4840	Truck Transportation
67	4850	Transit and Ground Passenger Transportation
68	4860	Pipeline Transportation
69	48B0	Scenic and Sightseeing Transportation and Support Activities for Transportation
70	49A0	Postal Service and Couriers and Messengers
71	4930	Warehousing and Storage
72	5120	Motion Picture and Sound Recording Industries
73	5131	Radio and Television Broadcasting
74	51B0	Publishing, Pay and Specialty TV, Telecommunications, and Other Information Services
75	5A01	Monetary Authorities and Depository Credit Intermediation
76	5A02	Insurance Carriers
77	5A03	Lessors of Real Estate
78	5A04	Owner-Occupied Dwellings
79	5A05	Rental and Leasing Services and Lessors of Non-Financial Intangible Assets (except Copyrighted Works)
80	5A06	Other Finance, Insurance and Real Estate and Management of Companies and Enterprises
81	5418	Advertising and Related Services
82	541A	Legal, Accounting and Architectural, Engineering and Rel. Svcs
83	541B	Computer Systems Design and Other Professional, Scientific and Technical Services
84	5610	Administrative and Support Services
85	5620	Waste Management and Remediation Services
86	611A	Educational Services (except Universities)
87	62A0	Health Care Services (except Hospitals) and Social Assistance
88	7100	Arts, Entertainment and Recreation
89	7200	Accommodation and Food Services
90	8110	Repair and Maintenance
91	813A	Grant-Making, Civic, and Professional and Similar Organizations
92	81A0	Personal and Laundry Services and Private Households
93	NP11	Religious Organizations
94	NP12	Non-Profit Welfare Organizations

Index	Code	Industry name
95	NP13	Non-Profit Sports and Recreation Clubs
96	NP19	Other Non-Profit Institutions Serving Households
97	NP20	Non-Profit Education Institutions
98	GS11	Hospitals
99	GS12	Government Residential Care Facilities
100	GS21	Universities
101	GS22	Government Education Services
102	GS40	Other Municipal Government Services
103	GS50	Other Provincial and Territorial Government Services
104	GS60	Other Federal Government Services

Annex C
Margins and Primary Inputs in DIO 4.1

Table C.1: Margins in DIO 4.1

Index	Margin
54001	Pipeline transportation of natural gas
54002	Crude oil and other pipeline transportation
5421	Grain storage
5470	Gas distribution
5500	Wholesaling margins
5531	Retailing margins
5830	Transportation margins
5960	Indirect taxes on products

Table C.2: Transport sub-margins in DIO 4.1

Index	Sub-margin
5302	Air transportation, freight
5232	Other services incidental to transportation
5332	Water transportation, freight
5333	Water transportation, other
5340	Services incidental to water transportation
5352	Rail transportation, freight
5360	Truck transportation

Table C.3: Primary inputs in DIO 4.1

Index	Primary Input
5960	Indirect taxes on products
5971	Subsidies on products
5972	Other subsidies on production
5980	Other indirect taxes on production
5990	Wages and salaries
6000	Supplementary labour income
6010	Mixed income
6020	Other operating surplus

List of abbreviations

CARO	Centre d'analyse et de recherche opérationnelle
CBoC	Conference Board of Canada
CF	Canadian Forces
CGE	Computable General Equilibrium
CIM	Consumer induced multiplier
CORA	Centre for Operational Research and Analysis
CSDRM	Centre for Studies in Defence Resource Management
DET	Defence Economics Team
DFECS	Directeur - Finances et établissement des coûts (Stratégie)
DIO	Defence Input-Output Model
DND	Department of National Defence
DRDC	Defence Research and Development Canada
DSEA	Directorate of Social and Economic Analysis
DSFC	Director Strategic Finance and Costing
IMF	International Monetary Fund
I-O	Input-Output
IAD	Industry Accounts Division
L	Link level of aggregation
M	Medium level of aggregation
MDN	Ministère de la Défense nationale
MS DOS	Microsoft Disk Operating System
ORAE	Operational Research and Analysis Establishment
R&D	Research and Development
RDDC	Recherche et développement pour la défense Canada
S	Small level of aggregation
SC	Statistics Canada
TM	Technical Memorandum
TN	Technical Note
W	Worksheet level of aggregation
WP	Worksheet Public level of aggregation

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The Department of National Defence (DND) spends over $10 billion per year on goods and services mostly purchased from Canadian suppliers. The economic activity generated by DND purchases is typically assessed using National Input-Output models developed by Statistics Canada. Using Statistics Canada's latest economic data, the Centre for Operational Research and Analysis's Defence Economics Team developed a tailored Input-Output model adapted to the defence industrial sector. The Defence Input-Output model version 4.1 (DIO 4.1) builds on past Input-Output models developed by the Centre for Operational Research and Analysis and features for the first time an interactive and Excel-based user interface. With DIO 4.1, DND staff can run simulations to assess the domestic impact of decisions regarding major equipment purchases and improve on the quality of impact assessments. This technical memorandum documents the economic foundation of Input-Output models as well as the calculations behind DIO 4.1 and a short user guide.

Le ministère de la Défense nationale (MDN) consacre plus de 10 milliards de dollars par an à l'achat de produits et services provenant essentiellement de fournisseurs canadiens. L'activité économique générée par les achats du MDN est habituellement évaluée à l'aide du modèle national des entrées-sorties mis au point par Statistique Canada. À l'aide des plus récentes données économiques recueillies par Statistique Canada, l'équipe des économistes de la défense du Centre d'analyse et de recherche opérationnelle (CARO) a créé un modèle d'entrées-sorties adapté à l'industrie de la défense. La version 4.1 du modèle prend appui sur de précédents modèles d'entrées-sorties mis au point par le CARO et offre pour la première fois une interface utilisateur interactive Excel. Grâce à la version 4.1, le personnel du MDN peut exécuter des simulations pour évaluer l'incidence nationale de grands achats d'équipement et améliorer la qualité des études d'impact. Le présent mémorandum technique explique les fondements économiques des modèles d'entrées-sorties et les calculs qui ont donné naissance à la version 4.1, ainsi qu'un bref guide de l'utilisateur.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus. e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus-identified. If it not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title).

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